5.0 AFFECTED ENVIRONMENT

This section of the DEIR describes the environmental and human resource characteristics of the preferred aquatic disposal sites. Documentation of existing conditions provides a baseline against which the impacts of the four preferred aquatic disposal alternatives, described in Section 4, can be analyzed. Impacts will be discussed further in Section 6. The preferred disposal sites are:

1. G-Cell-1: A portion of the northern corner of G3-ATC and a portion of the adjacent southwest corner of G2-OD.
2. G-Cell-2: A portion of the western corner of G3-ATC and adjacent areas.
3. G-Cell-3: A portion of the southern corner of G3-ATC and adjacent areas
4. G-Cell-4: A portion of the northeastern corner of G3-ATC and a portion of the adjacent southeastern corner of G2-OD.

In this section, the environmental and human aspects of these sites are characterized and their surroundings are described.

5.1 Location and Hydrography

Gloucester Harbor is located on the north shore of the Massachusetts coast and borders the communities of Rockport to the east, and Manchester-By-The-Sea and Essex to the west (Figure 5-1). It is approximately 30 miles north of Boston and 25 miles south of Portsmouth, NH. Gloucester Harbor is a coastal embayment with a mean tidal range of 8.7 feet or 2.65 meters (NVAI, 1996). There are no significant freshwater inflows to the harbor. However, the Annisquam River, a tidal stream fed by fresh water tributaries, drains into the Western Harbor area of the Gloucester Outer Harbor. The Outer Harbor mouth lies at an imaginary line which extends from Mussel Point, east to the Dogbar Breakwater at Eastern Point (Figure 5-2). Gloucester Harbor has various smaller coves and embayments between rocky headlands around its perimeter. Beginning from the mouth of the Harbor on the western shore and proceeding in a clockwise direction, the following distinct regions of the harbor are delineated: Old House cove lies between Mussel Point and Dolliver Neck. To the north, Freshwater Cove lies between Dolliver Neck and the rocky headland of Stage Head. Continuing northeasterly, the Western Harbor embayment lies between Stage Head to the west and Fort Point to the east. At this location, the Annisquam River bisects the Western Harbor. Proceeding southeasterly from Fort Point, the mouth of Gloucester Inner Harbor lies between Fort Point and Rocky Neck. Southeast of Rocky Neck lies Wonson's Cove on the eastern side of Gloucester Harbor. Proceeding southerly to the Eastern Point Breakwater, lies first the Southeast Harbor, then the headlands of Black Bess point, and finally Lighthouse Cove. Ten Pound Island, another major geographical feature of the Harbor, lies within the Gloucester Harbor just outside the mouth of the Inner Harbor. In addition, numerous submerged or partially submerged rocks, reefs and ledges lie around the perimeter of the Outer Harbor.

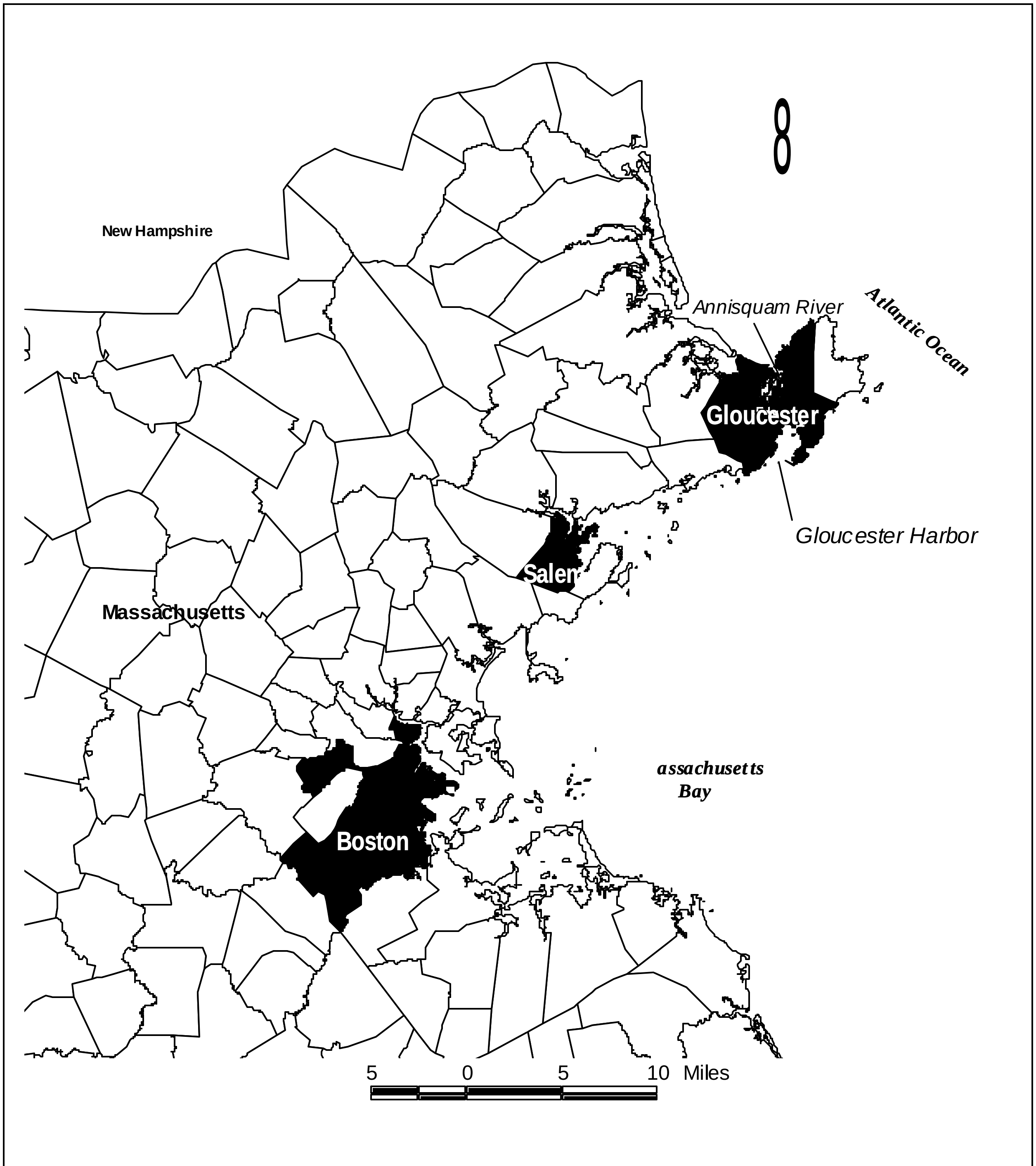

Figure 5-1: Location of Gloucester Harbor

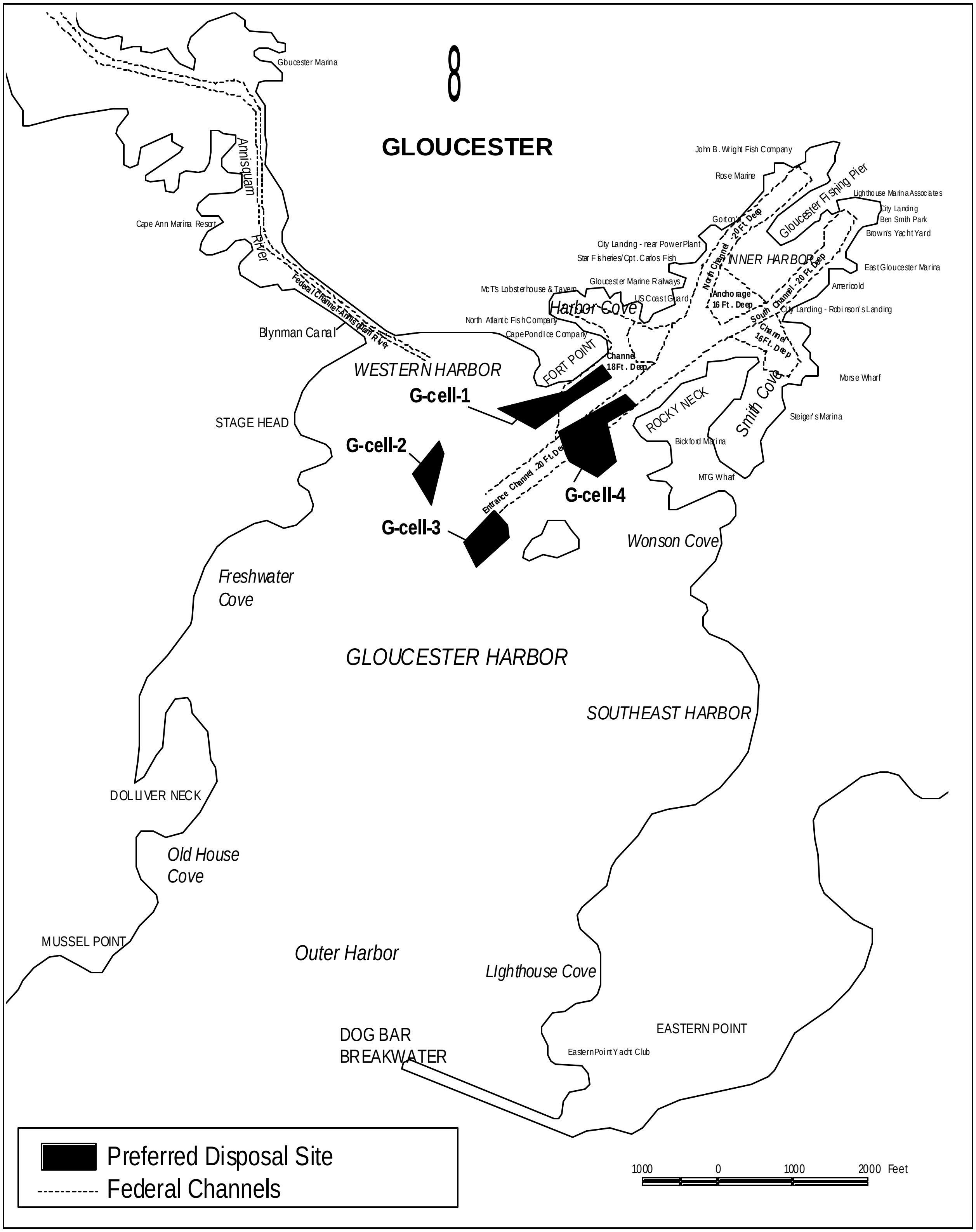

Figure 5-2. Federal Channels in Gloucester Harbor

Smaller coves also lie within the Gloucester Inner Harbor. Harbor Cove is located on the western side of the Inner Harbor. Harbor Cove accommodates numerous marinas and docking facilities for commercial fishing and recreational boats. Smith Cove is located on the south eastern side of the Inner Harbor.

The Blynman Canal provides navigational access to the Annisquam River via the Western Harbor. The channel is authorized to a depth of 8 feet (2.4 meters). Authorized depth refers to the channel depth (mean low water) that is needed to accommodate the drafts of vessels that use the channel. The USACE is responsible for maintaining channels at the authorized depth so long as economic justification can be established. Five other channels provide access to and within the Inner Harbor: the Main or Entrance Channel, the North Channel and South Channels, Harbor Cove Channel and Smith Cove Channel.

The main federal navigation channel leading into Gloucester Inner Harbor (the Entrance Channel) is authorized to a depth of 20 feet (6.1 meters). It terminates at the Inner Harbor Anchorage Area, which has an authorized depth of 16 feet (4.9 meters). Here the channel forks into the North and South Channels relative to the State Fish Pier. North of the entrance channel lies Harbor cove and its entrance channel and anchorage areas. The Harbor Cove channel has an authorized depth of 18 feet (5.5 meters); the adjacent anchorage area 15 feet (4.6 meters). Both the north and south channels of the Inner Harbor have an authorized depth of 20 feet (6.1 meters). Smith Cove channel has an authorized depth of 16 feet or 4.9 meters (ACOE, 1992). Figure 5-2 depicts the location of the navigation channels in the harbor.
The harbor contains several marinas, a significant recreational fleet, harborside historical attractions, and various commercial fishing fleets and fish processing/cold storage facilities (Figure 5-2).

5.2 Regulatory Environment

Disposal of dredged material and UDM in the aquatic environment of Gloucester Harbor falls under the jurisdiction of several federal and state environmental programs. The principal federal jurisdiction is Sections 401 and 404 of the CWA, which regulates the disposal of dredged material and UDM in open water landward of the baseline of the territorial sea. Because the candidate aquatic disposal sites are landward of the territorial sea baseline, they are not regulated by Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA) (a.k.a. Ocean Dumping Act).

The Section 401 Water Quality Certification program is administered by the DEP. A Water Quality Certificate must be issued for the disposal of dredged material and UDM within the limits of state waters, which extend from the shoreline seaward for three miles, or to the territorial sea baseline.

Other state regulatory programs include the Public Waterfront Act (Chapter 91 of the Massachusetts General Laws or MGL) and the Wetlands Protection Act, which govern dredged material and UDM disposal activities in the aquatic environment.

5.3 Marine Resource Characterization

Existing information pertinent to Gloucester Harbor was collected and reviewed to characterize general sedimentary environments in the vicinity of Gloucester Harbor. Recent fisheries information collected during the Salem Sound Resource Assessment, by the DMF, and surveys for this project, was used in the characterization of existing fisheries and habitat resources of the region. Natural resources mapping prepared by the DEP (eelgrass) and data provided by the Massachusetts Geographic Information System (MassGIS) office (wetland resources) were also used.

Site-specific field studies were performed at each of the candidate sites to collect Sediment Profile Images (SPI) using the REMOTS® camera system (Rhoads and Germano, 1982;1986). These sediment-profile images provide valuable site-specific information on sediment types and biological activity.

Sediments to be dredged from within the channnel were tested in 1997 to determine their suitability for unconfined aquatic disposal. The physical and chemical characteristics of the sediments at aquatic disposal sites were also determined.

A subbottom profile survey was conducted to determine the depth to bedrock in Gloucester Harbor. This information was needed to estimate the potential capacity of the proposed CAD sites in the Harbor.

5.3.1 Sediments and Water Quality

Data regarding sediments (physical characterization, transport and circulation, and sediment quality was obtained from various regional and site specific studies including the following:

- Habitat characterization of the DMMP Candidate Aquatic Disposal Sites report to MACZM (Maguire Group, 1999);
- An engineering assessment report for the Americold and Gorton's wharves (NVAI, 1996)
- The early benthic phase lobster report (Normandeau, 1999)

Water quality and water quality classification information was obtained from the following sources:

- Massachusetts Division of Marine Fisheries Designated Shellfish Growing Areas (MADMF, 1999)
- A Massachusetts Division of Marine Fisheries report on the marine resources of the Beverly-Salem Harbor (Jerome et al, 1967),
- A Massachusetts Division of Marine Fisheries report on the effects of the addition of a fourth generating unit at the Salem Harbor Electric Generating Station on the Marine Ecosystem of Salem Harbor (Anderson et al, 1975).
- An estuarine eutrophication survey conducted by the National Oceanic and Atmospheric Administration (NOAA, 1997).
- The DMMP, Phase I (Maguire Group, 1997).
- Other literature (Riley, 1967),(Hiscock, 1986),(Knebel, 1996).

5.3.1.1 Physical Characterization of Existing Sediments

Fine-grained unconsolidated sediments were found throughout the Gloucester G-cell sites and within Gloucester Harbor in general. This type of sediment suggests a low-energy, depositional environment which is typical of protected coastal embayments with limited freshwater inflow and a moderate tidal influence. Tests on composite grain samples taken from the upper two feet (0.6 meters) of sediment revealed that sediment from within and near the G-Cell sites were predominantly within the silt to clay grain size range (Maguire Group 1997).

Sediment-profile image data proximal to the G-Cell sites provided further insight into the sediment character. The majority of Gloucester Inner Harbor sites showed relatively high RPD values, indicating adequate sediment aeration, due to the effects of tidal flushing, and via bioturbation by Stage III benthic invertebrate organisms (subsurface deposit-feeders). REMOTS® images depicted fine-grained unconsolidated sediments with benthic invertebrate community successional designations of Stage I on III. RPD depths ranging from 4.39 to 7.95 cm were characteristic of the G-Cell sites. These successional designations and RPD values are indicative of low to mid energy regimes and thus net depositional environments. Lower RPD values and a Stage I designation are normally indicative of high-disturbance/degradation regimes in which the disturbance/degradation results in impact to habitat integrity. Distinguishing biological features, such as juvenile and adult lobster burrows, were also observed by divers on the seafloor surface during assessments conducted along transects oriented across the harbor (NAI 1999).

All images obtained in the vicinity of the G-Cell Sites had Organism-Sediment Index (OSI) values of +11 or greater, suggesting good or healthy overall benthic habitat quality. The OSI is a metric which defines overall benthic habitat quality by reflecting the depth of the apparent redox layer, successional stage of infauna, the presence/absence of methane gas in the sediment, and the presence/absence of reduced (i.e. anaerobic) sediment at the sediment-water interface. The high values determined for these sampling stations in or proximal to the G-Cell sites reflect the widespread presence of Stage I and bioturbating Stage III organisms coupled with relatively deep apparent RPD depths (Maguire Group 1999). A more detailed discussion of habitat conditions is presented in Section 5.2.3.2.

5.3.1.2 Sediment Transport/Circulation in the Vicinity of Disposal Sites

The circulation of water in coastal embayments such as Gloucester Harbor is influenced by a complex combination of forces produced by basin morphology, tidal fluctuations, wind, and density gradients. Although general information about present circulation conditions within these harbors has been collected (see below), no data exist describing the actual sediment transport and circulation patterns in Gloucester Harbor, particularly within the G-Cell sites and proximity. Factors affecting potential sediment transport at this site is dependent on disposal site design.

Detailed site-specific information is required to project the fate of UDM placed at this location. At present, understanding of the magnitude and seasonal/spatial components of these physical forces is insufficient to quantify the long-term stability of UDM at the preferred disposal sites. Detailed, *in situ* measurements of tides, circulation, and patterns of sediment resuspension will be evaluated at the preferred disposal site. This includes deployment of a tide gauge; current meters to provide a vertical profile of flows, bottom shear stress, and wave height; and an OBS (optical backscatter) meter to determine the relationship between wave heights, water currents, and sediment resuspension.

Nevertheless, the general sediment transport and circulation conditions within the vicinity of the G-Cell sites can be assessed using the existing available information to quantitatively determine the suitability of the proposed sites (refer to section 6.1.2). Circulation patterns within Gloucester Harbor are primarily driven by meteorological events and mixed semi-diurnal tidal currents. Mean tidal amplitude within the harbor is approximately 8.7 ft (NVAI, 1996).

Meteorological forcing and storm-driven events may have a strong influence on sediment resuspension in the region. In Massachusetts Bay, sediment resuspension is most prominent during the late fall through early spring when large waves from the northeast, north, and northwest are generated by storms. During spring and summer, winds are typically from the southwest and west, waves are smaller and weaker, and resuspension is less likely (Knebel et al. 1996). However, Gloucester Harbor is oriented to the southwest which makes it less susceptible to the more erosive storms and waves originating from the northeast throughout the winter. Data collected from NOAA's National Weather Service, Beverly Station, indicate that wind from the N and NE (300-360E) primarily occurs in winter and fall (Figure 5-3). Average winds are highest during these seasons (Figure 5-4) as is the frequency and duration of gusting winds from the NE (Figure 5-5). Relatively long expanses of open water with nearby depths off-shore are conducive for the development of large waves from winds out of the north and northeast. Due to Gloucester's orientation to the southwest, the harbor escapes much of the high energy storm driven winter waves of the region which come from the northeast.

5.3.1.3 Water Quality Classifications

DEP has established Water Quality Classifications for the Commonwealth's surface waters, as listed below. The Gloucester cell sites are located within an area designated as SB (Figure 5-6). Class SB waters are designated as a habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. The state's goals for Class SB water is to provide suitable water quality to sustain shellfish harvesting with depuration (Restricted Shellfish Areas), and to maintain consistently good aesthetic value.

The preferred aquatic disposal sites are proximal to SA waters. SA waters are designated as an excellent habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting without depuration (Open Shellfish Areas). The waters off Cape Ann within the Rockport town boundary and extending out to the 3 mile state boundary are designated as Class SA waters. North of Gloucester Harbor, SA waters lie within the upper reaches of the Annisquam River and Ipswich Bay.

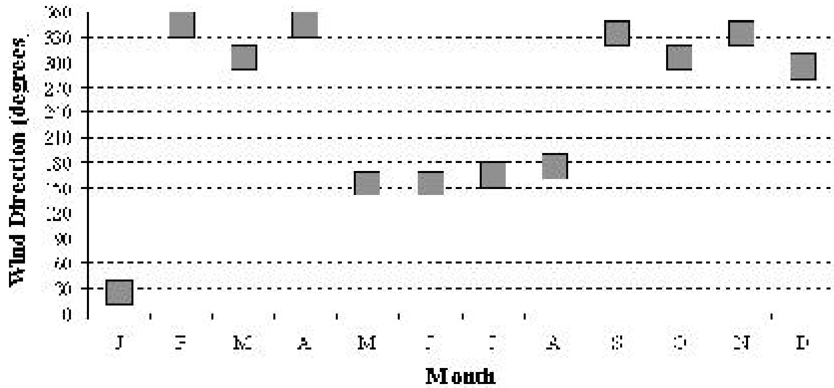

Figure 5-3: Prevailing Wind Direction by Month (1998) Recorded at Beverly Airport

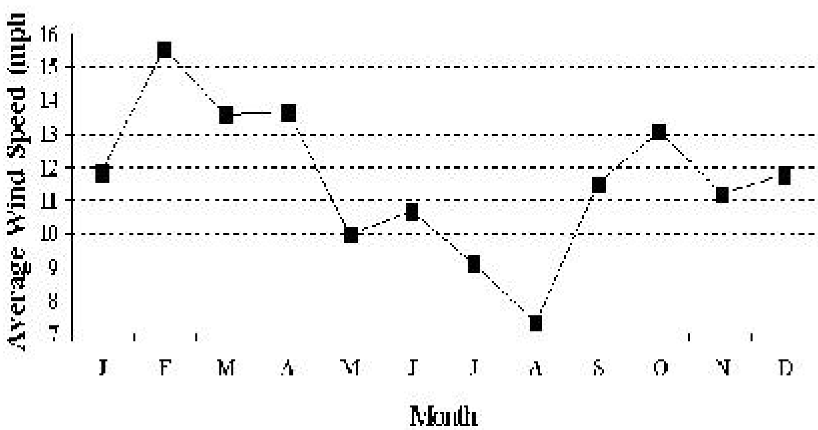

Figure 5-4: Average Wind Speed by Month (1998) Recorded at Beverly Airport

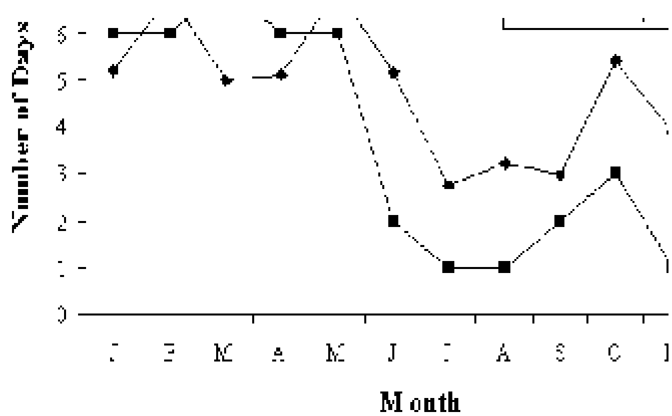

Figure 5-5: Number of Days/ Wind Speed by Month (1998) for Wind Gusts from the NE Recorded at Beverly Airport

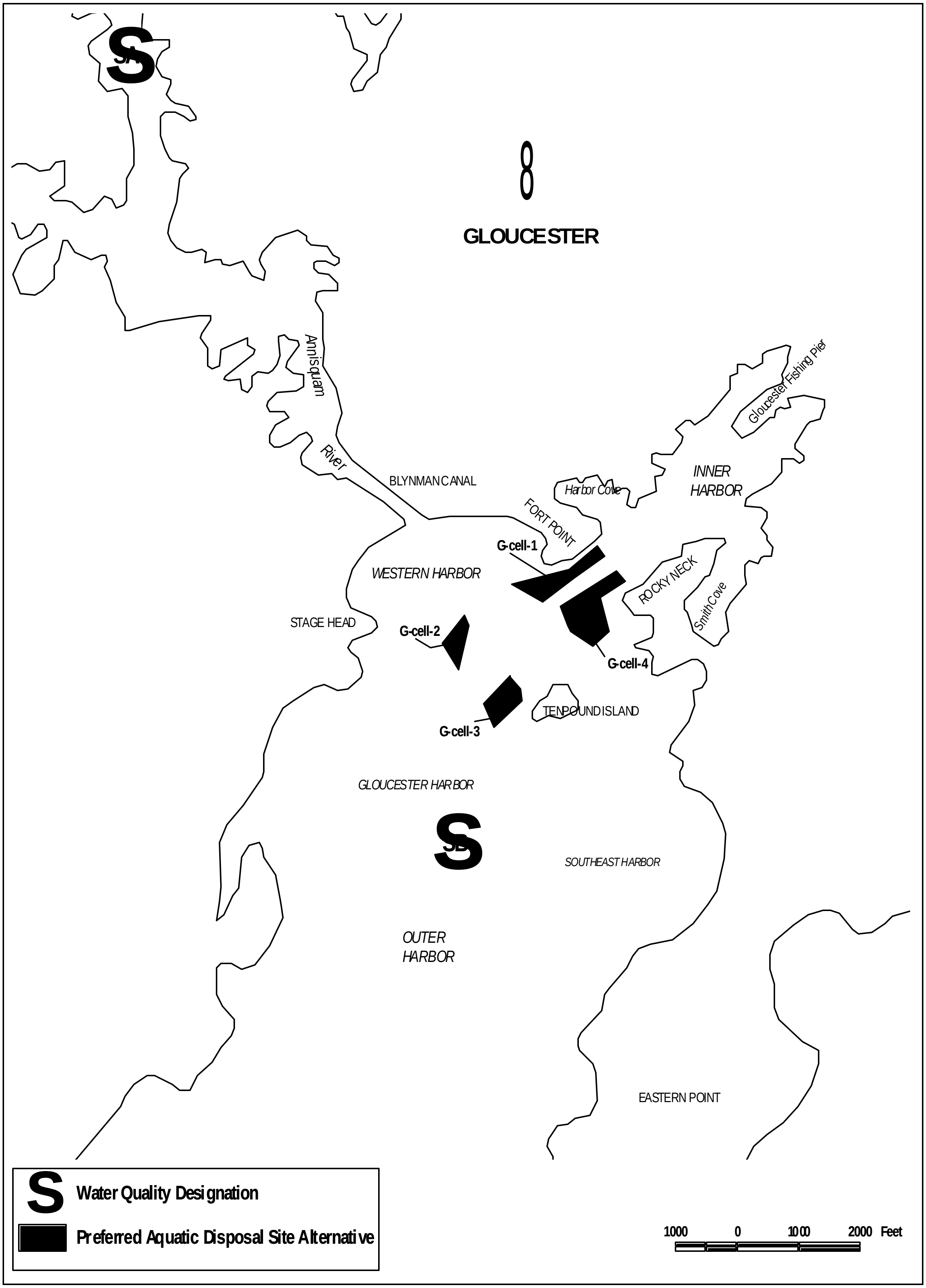

Figure 5-6. Water Quality Classifications of Gloucester Harbor and Annisquam River

In addition to the classification system for surface waters, the Commonwealth has also denoted specific subcategories of use assigned to water segments that may effect the application of criteria or specific antidegradation provisions of 314 CMR 4.05. Those restrictions pertinent to the siting of a disposal site for UDM from Gloucester Harbor include:

<u>Shellfishing</u> – open shellfishing areas are designated as "(O)" and restricted shellfishing areas are designated as "(R)." These waters are subject to more stringent regulation in accordance with the rules and regulations of the DMF pursuant to M.G.L. c. 130 § 75. These include applicable criteria of the National Shellfishing Sanitation Program. Shellfish Growing Area Designations by the DMF indicate that all of Gloucester Harbor, and its associated embayments and coves, and an area extending 3 miles into the ocean off Gloucester are currently classed as prohibited areas for fishing (MADMF 1999).

<u>CSO</u> – These waters are identified as impacted by the discharge of combined sewer overflows in the classification tables in 314 CMR 4.06(3). Overflow events may be allowed by the permitting authority without variance or partial use designation. Gloucester Harbor is designated a CSO area.

<u>Water Quality</u> - Historically, waters of Gloucester Harbor were utilized for the disposal of raw industrial and domestic sewage, as is typical of many tidal bays and estuaries in Massachusetts. Pollution and the subsequent reduction in water quality have been a contributing factor to the disappearance of important commercial and recreational finfish species, as well as the closure or restriction of harvesting from shellfish beds (Jerome et al. 1967). Currently, the sewage outfall lies well outside of Gloucester Harbor.

Water quality measurements have been taken in several north shore locations including Salem and Gloucester Harbors. Gloucester data from NAI (1999), USACE (1985), and Anderson et al. (1975) are summarized herein. Basic water column chemistry data (temperature, salinity, dissolved oxygen, turbidity) from the Salem Sound Resource Assessment Study (SSRAS) was reviewed as part of this study and the data collected from other north shore harbor locations corroborates the data collected by the aforementioned authors in Gloucester. The SSRAS was used to portray expected phytoplankton conditions in Gloucester. Even though the SSRAS stations were not located in Gloucester Harbor proper, the similarities in oceanography, latitude, and water depth at other stations in the north shore region are representative of Gloucester Harbor.

Generally, as one moves from oceanic water areas landward toward and into enclosed coastal waters, one can expect greater turbidity, wider temperature ranges, higher nutrient concentrations and more variable salinity (Hiscock, 1986). In Gloucester Harbor, water temperature, salinity and dissolved oxygen (DO) were collected during lobster and finfish sampling efforts (seining and trawling) from June 1998 through May 1999 (NAI, 1999) (refer to Sections 5.2.3.5 - lobsters, and 5.2.4 finfish, sections). During this study, water quality sampling conducted at each seine and trawl sample stations revealed that monthly mean water temperature followed a predictable seasonal pattern. Water temperatures were generally highest in September (seine: 17.4 ^{o} C; trawl: 15.3^{o}C) and lowest in March (seine: 3.2 ^{o} C; trawl: 2.8^{o}C). Salinity did not vary appreciably during the months sampled. In the seine, monthly mean salinity ranged from 29.1 ppt at one seine station (GS1) in May, to 32.1 ppt at other seining stations (GS2 and GS3) in January.

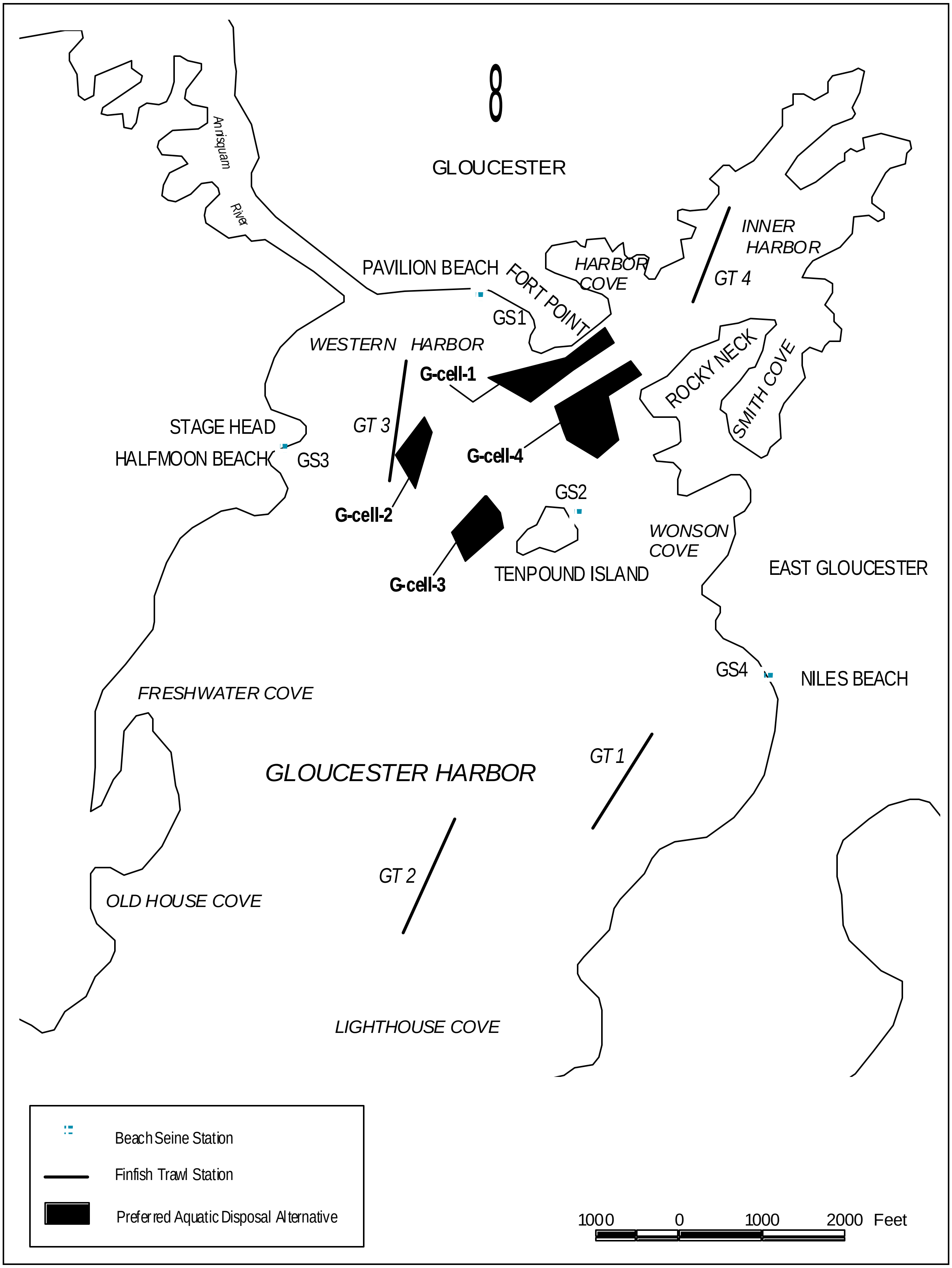

Figure 5-7. Beach Seine, Finfish Stations and Water Quality Monitoring Stations.

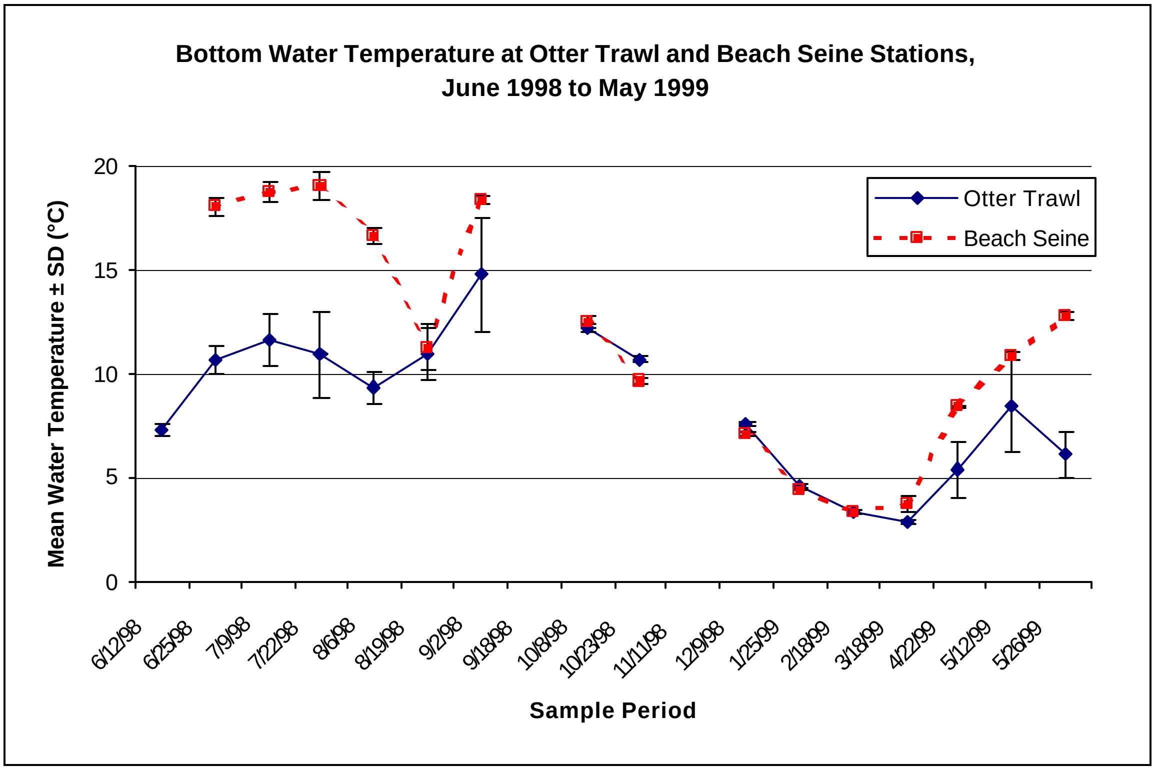

Figure 5-8: Bottom water temperature of otter trawl and beach seine stations in Gloucester Harbor, June 1998 to May 1999 (NAI 1999).

Monthly mean salinity in the trawl ranged from 30.4 ppt at one location (GT3) to 32.9 ppt at another (GT1) in May. These salinity values are very similar to average oceanic salinity and reflect the limited freshwater input and strong tidal influence in Gloucester Harbor. Monthly mean dissolved oxygen was never lower than 8.8 mg/l in the seine samples (GS3 in October) and 9.8 mg/l in the trawl samples (GT4 in May). These levels of DO were near saturation during the months collected and were not limiting to fish distribution.

The USACE measured salinity within Smith Cove at –25 parts per thousand (‰) at the surface and –28 ‰ at a depth of >1 meter below the surface (ACOE, 1985).

The SSRAS found that turbidities were highest within or proximal to the major drainages entering Salem Sound such as the Upper and Lower Danvers River during May through June. This is attributed to freshwater inflow, since suspended sediments are typically highest during spring, due to seasonal increases in precipitation and resultant runoff. Similar patterns are expected for the Annisquam River and western portion of Gloucester Harbor. Exceptionally high turbidities can also be expected form suspended sediment in areas relatively exposed to tidal or storm induced wave energy.

Anderson et al. (1975) reported that a seasonal variation in phytoplankton production, as estimated by chlorophyll *a* concentration, was evident within Salem Harbor. In Gloucester Harbor, seasonal patterns and bloom conditions similar to those reported for other estuaries within the same ecoregion (i.e.: boreal temperate climates) are expected. High temporal and spatial variability in chlorophyll concentration is characteristic of shallow near shore embayments, caused by fluctuations in riverine inflow, wind-driven turbulence, or patchy nutrient distribution. The first and largest bloom typically occurs in late winter to early spring with the warming of surface waters and the introduction of nutrients from freshwater inflow. Chlorophyll *a* concentration ranged from 0.69 to 29.08 mg/m^3 over the course of the Salem Sound study (July 1973-December 1974), and algal concentrations were estimated to be moderate (from 5 to 20 mg/m^3; NOAA 1997). NOAA's (1997) Estuarine Eutrophication Survey estimated that nuisance algal blooms typically do not have an impact on biological resources in the region.

5.3.1.4 Sediment Quality

Sources of potential contamination within Gloucester Harbor were evaluated during the Due Diligence review. As part of the Due Diligence review, a database search of existing local, state, and federal environmental files for reported releases of regulated substances (e.g. oil, hazardous chemicals) was conducted (Maguire Group, 1997). The results of this review revealed five reported hazardous or other regulated materials release incidents for Gloucester Harbor, however, details regarding the identity, quantity and exact location of release were seldom recorded in the incident reports. Available details regarding these releases (as recorded on the incident reports) are provided in Table 5-1.

Table 5-1: Reported Releases of Hazardous and Other Regulated Materials within Gloucester Harbor and Annisquam River from 1990 to 1997.

State or Federal Incident ID #	Location as Reported	Report Date	Material	Quantity	Units
N90-1341	Smith Cove	8/13/90	Diesel Fuel	101-250	Gallons
N92-1428	Annisquam River @ Squam Rock Road	10/30/92	other	1-10	Drums
N93-1235	International Seafood Pier	9/14/93	Petroleum	Unknown	Unknown
3-0011013	Gloucester Harbor	5/17/94	Oil	Unknown	Unknown
N93-1045	Harbor Cove	8/4/93	Diesel Fuel	Unknown	Gallons

The shoreline of Gloucester Harbor is a dense mix of residential, commercial and industrial land uses (Maguire Group Inc., 1997). There are nine (9) facilities permitted to discharge wastewater under the National Pollutant Discharge Elimination System (NPDES) within the Gloucester Harbor area. All but one are classified as minor discharge facilities. The remaining site, the Gloucester Water Pollution Control Facility, is classified as a major source of discharge and is located along the Annisquam River (Figure 5-9), however, discharge is well outside of the harbor. Existing and historical combined sewer outfalls have likely contributed pollutants to the Inner Harbor.

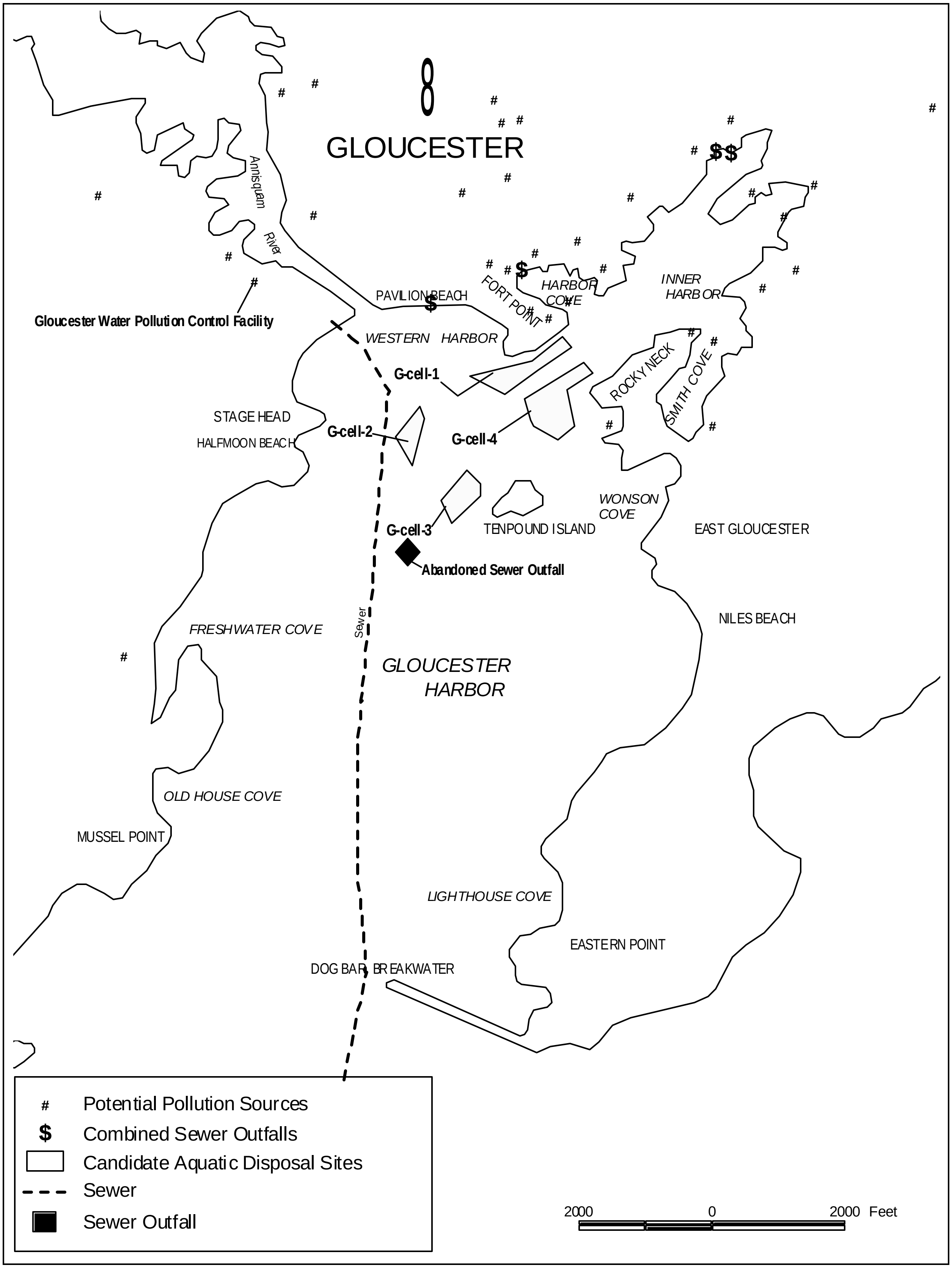

Figure 5-9. Potential Pollution Sources in Gloucester Harbor and Annisquam River

Sediment quality testing conducted in Gloucester Inner Harbor Federal Channel in 1997, confirmed the presence of total copper, total lead, and total PAHs in excess of Massachusetts Bay Disposal Site Reference Criteria. These results were anticipated due to the proximity of adjacent waterfront pollution sources, and the historic sediment contamination in this area (Maguire Group 1997). The following specific chemical concentration ranges were measured: lead 86 ppm; copper 62 ppm; and total PAH 12,372 ppb compared to reference values of 66.3, 31.7, and 2,996 respectively.

Potential sources of pollutants remain in the harbor watershed, due to the number of high risk industry within the commercially developed areas surrounding the harbor. For instance, the known 50 state hazardous waste sites within the Gloucester Harbor waterfront have been responsible for the release of PCBs, petroleum hydrocarbons, volatile organic compounds, and heavy metals to the soil, surfacewater, groundwater, and sediment media around the harbor. These sites include numerous gasoline filling stations, automotive service stations, fuel companies; autobody repair shops, and various industrial facilities.

Table 5-2: Selected Surficial Sediment Chemistry Results from Sampling within Annisquam River Channel and Gloucester Inner Harbor Federal Channel.

PARAMETER	UNITS	Annisquam River	Federal Channel	MBDS Reference
% Fines(silt/clay)	%	8%	85%	88%
Metals				
Arsenic	ppm	0.965	12	28.7
Cadmium	ppm	0.17	0.98	2.74
Chromium	ppm	0.13	35	152
Copper	ppm	9.71	**62**	31.7
Mercury	ppm	0.053	0.24	0.277
Nickel	ppm	4	16.7	40.5
Lead	ppm	19.3	**86**	66.3
Zinc	ppm	55.6	127.8	146
Other Parameters				
Total PAHS	ppb	2,670	**12,372**	2,996
Total PCB Congeners	ppb	38	113	ng

ng = no guideline
numbers in **bold** are above MBDS reference

5.3.2 Benthos

5.3.2.1 General

The term benthos refers to the community of organisms living in or on top of the sediments. For the purposes of this report, the term does not include finfish, although some finfish may live on the bottom (e.g. winter flounder). Benthic organisms include those valued for human consumption such as lobsters, clams, mussels, as well as many non-commercial species such as segmented worms, other bivalves, and various crabs.

The benthos of Gloucester Harbor is discussed in four categories. First, the overall benthic habitat is described based on a REMOTS® survey (Maguire, 1999) done in 1998, for this project. Second, the benthic invertebrate population is described, although limited information exists on the non-commercial benthos in Gloucester Harbor. Third, the commercially and recreationally harvestable mollusks are discussed based on surveys conducted primarily by DMF (e.g.: the Salem Sound Resource Assessment). Finally, the lobster habitat of Gloucester Harbor as a whole is evaluated based upon a recent early benthic phase lobster (EBP) survey (NAI, 1999), historic DMF studies, and DMMP-specific lobster sea-sampling.

Information regarding benthic invertebrates and benthic invertebrate habitat include the following sources:

- Habitat Characterization of the DMMP Candidate Aquatic Disposal Sites (Maguire Group, 1999)
- Early Benthic Phase Lobster Survey for Gloucester Harbor (NAI, 1999),
- DMF mapping of shellfish resources in Gloucester Harbor (DMF, 1999),
- A study of the marine resources of the Annisquam River-Gloucester Harbor Coastal System (Jerome, et al, 1969)
- other available literature (Robbins and Yentsch, 1973), (USACE, 1975), (Gosner, 1978), (NAI, 1987).

5.3.2.2 Benthic Habitat Conditions

In an effort to gain some general information on benthic habitat conditions at the candidate aquatic disposal sites Valente, et. al., (1999) conducted REMOTS® sediment-profile imaging surveys. The REMOTS® system uses a specialized camera to photograph a vertical cross-section of the sub-bottom to a depth of 15 to 20 cm. Data obtained from the photographs include sediment type, presence of macrofauna, presence of methane bubbles, and depth of oxidized sediments. The depth of oxidized sediments is apparent in the photographs as the boundary between colored surface sediment and underlying gray to black sediment, called the apparent redox potential discontinuity (RPD). The depth of the RPD is increased by the presence of bioturbating macrofauna. The foregoing parameters can be used to determine habitat type and infaunal successional stages, and to calculate an Organism-Sediment Index (OSI), an indicator of habitat quality of soft-bottom benthic environments. OSI values of less than 0 indicate degraded habitat quality, values of from 0 to +6 reflect intermediate quality, and values greater than +6 are indicative of good quality or healthy benthic habitats. During REMOTS® sampling, various sampling locations were chosen within the three former proposed aquatic disposal sites (i.e. G1-CDF, G2-OD, and G3-ATC). Delineation of the Preferred Aquatic Disposal G-Cell sites was conducted after REMOTS® sampling was conducted. Therefore, each Preferred Aquatic Disposal Site (e.g.: G-Cell-1, etc) may not have a site specific REMOTS® sampling station within its boundary. Station 77 of the REMOTS®

sampling is located within G-Cell-1. REMOTS® sampling Station 74 is located within G-Cell-3. No REMOTS® sampling stations lie within G-Cells 2 or 4. However station 75 is proximal to G-Cell-2, while Stations 73 and 78 lie just outside of southwestern and northeastern limits, respectively, of G-Cell-4.

The results of the REMOTS® imaging obtained at each sampling station within or proximal to the Preferred Alternative Aquatic Disposal (G-Cell) Sites are presented in Table 5-3. The images indicate that the site is characterized by unconsolidated, fine-grained sediment having a grain size major mode of >4 phi (i.e., silt-clay). This resulted in the habitat type being classified as "unconsolidated soft bottom, very soft mud" (UN.SF) in both images. The predominance of fine-grained sediment, and the location of the site in the relatively calm waters at the mouth of the Inner Harbor, support the supposition that this is a depositional sedimentary environment. The penetration depth of the camera prism was between 11.05 cm (GL77) and 18.44 cm (GL78) below the sediment surface. These are intermediate to deep penetration depths which reflect the soft nature of the substrate.

Table 5-3. The results of the REMOTS® imaging obtained at sampling stations within or proximal to the Preferred Alternative Aquatic Disposal Sites

Preferred Aquatic Disposal Site	Former Cell Designation	REMOTS® Station No.	Benthic Invertebrate Successional Stage	Median Grain Size	Mean RPD (cm)	OSI	Habitat Type
G-Cell-1	Portions of G2-OD & G3-ATC	GL77	Stage I on III	>4 f	7.95	11	UNSF
G-Cell-2	Portion of G3-ATC	Proximal to GL75	Stage I on III	>4 f	6.5	11	UNSF
G-Cell-3	Portion of G3-ATC	GL74	Stage I on III	>4 f	4.56	11	UNSF
G-Cell-4	Portions of G2-OD & G3-ATC	GL 73	Stage I on III	>4 f	7.95	13	UNSF
		GL78	Stage III	>4 f	4.39	11	UNSF

Key: RPD: Redox Potential Discontinuity (Refer to Text for Definition)

OSI: Organism-Sediment Index (Refer to Text for Definition)

UNSF: Unconsolidated Bottom Substrate: Very soft Mud

The mean depth RPD depth ranged from 4.56 cm at GL74 to 8.72 cm at GL75. These are relatively deep RPD values indicative of good sediment aeration. The change in optical reflectance (i.e., color contrast) between the light-colored, aerobic surface sediment and the underlying dark, anoxic sediment is very distinct in each image (Figures 5-11a-d). The black color of the underlying sediment suggests a high inventory of sulfides and high sediment oxygen demand, possibly related to elevated levels of organic loading within the Inner Harbor.

The well-established RPD depths are indicative of good bottom oxygen supply at the time of the survey in November 1998. It is unknown whether reduced near-bottom oxygen levels are experienced in or proximal to the Inner Harbor as a result of water column stratification during warmer months. Such seasonal near-bottom hypoxia would be expected to result in shallower RPD depths during the late summer and early fall months.

The REMOTS® infaunal successional stage was consistently determined to be Stage I on III in images obtained from each REMOTS® sampling station within or proximal to the G-Cell sites. The evidence of Stage III in the image from the sampling stations is the presence of feeding voids visible in the images (Figure 5-10a). In these images, the Stage I designation is due to the presence of small, opportunistic, tubicolous polychaetes at the sediment surface. Both Stage I and Stage III organisms can co-exist and are known to exploit the fine-grained, organic-rich, soft mud which characterizes the site. The presence of larger-bodied, Stage III infauna helps to explain the relatively well-developed RPD depths at these sites (compared to RPD values of <2 at the northern limits of the Inner Harbor). The feeding and burrowing activities of Stage III deposit feeders (bioturbation) result in increased sediment aeration and hence deeper RPD depths.

The REMOTS® Organism-Sediment Index (OSI), an overall measure of benthic habitat quality, was calculated to be +11 at all stations but GL78 which is the northernmost sampling station within the Inner Harbor Channel. The relatively high OSI values at the site reflect both the well-developed RPD depths and the apparent presence of a mixture of Stage I and Stage III taxa. Overall, the REMOTS® images suggest that stations within or proximal to the G-Cell sites represent relatively healthy soft-bottom habitat (Figure 5-10b).

Figure 5-10a: Sediment Profile Image from Station 74b (G-cell-3) showing a silt-clay sediment type. This is an example of unconsolidated soft-bottom, soft mud habitat (UN.SF). The RPD depth, marked by the change in color between light-colored surface sediments and dark anoxic sediments, is distinct and relatively deep in this image (6.11 cm). A few small polychaete tubes at the sediment surface result in a successional designation of Stage I.

Figure 5-10b: Sediment Profile Image from Station 75b (proximity of G-cell-2) showing a silt-clay sediment type. This is an example of unconsolidated soft-bottom, soft mud habitat (UN.SF). The RPD depth is distinct and deep in this image (8.72 cm). Polychaete tubes at the sediment surface and infaunal feeding voids and burrows provide evidence for a successional designation of Stage I on III.

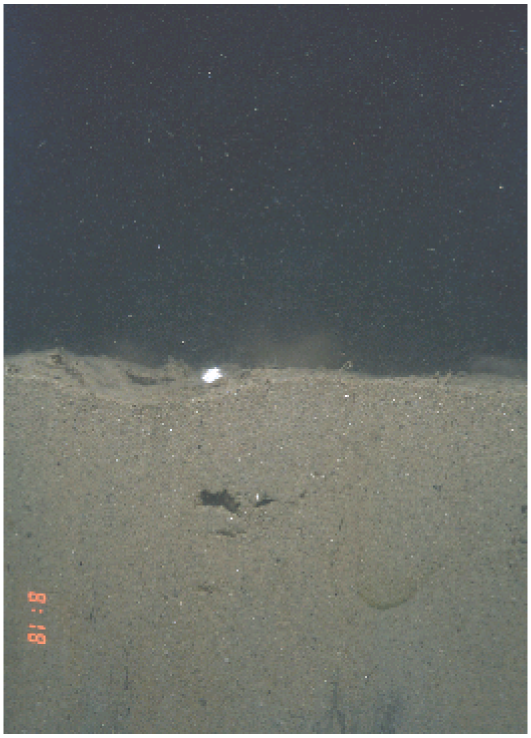

Figure 5-10c: Sediment Profile Image from Station 77b (G-cell-1) showing a silt-clay sediment type. This is an example of unconsolidated soft-bottom, silty habitat (UN.SI). The RPD depth is deep in this image (8.16 cm). A biogenic surface is evident and includes a shell fragment. Polychaete tubes at the sediment surface and an infaunal feeding void and burrow provide evidence for a successional designation of Stage I on III.

Figure 5-10d: Sediment Profile Image from Station 78b (G-cell-4) showing a silt-clay sediment type. This is an example of unconsolidated soft-bottom, soft mud habitat (UN.SF). The RPD depth in this image is (4.39 cm). Evidence of bioturbation is apparent as darker deeper sediment appears to have been deposited at the sediment surface. Feeding voids at depth are indicative of Stage III succession.

5.3.2.3 Benthic Invertebrates

The benthic invertebrate fauna of the Massachusetts coast north of Cape Cod are characteristic of the boreal biogeographical region (Acadian Province), which has colder temperatures and less summer warming, and therefore a smaller annual temperature range, than waters south of Cape Cod. Waters from Cape Cod south to Cape Hatteras, North Carolina lie within the Virginia Province of the American Atlantic Temperature Region. Many boreal species reach the southern limit of their range at Cape Cod, and it is there that many temperate species reach their northern range limit (Gosner, 1978).

Comprehensive benthic invertebrate sampling was not done, *per se*, at any of the candidate disposal sites. However, previous studies in the region (Jerome *et al*. 1967, ACOE 1975, NAI 1987) contain some information on the abundance and type of benthos in Salem Harbor. Other studies provide information on distinct areas of Gloucester Harbor (NVAI 1996, USACE 1986). Still other ancillary information was generated during other studies conducted for this project. For instance, REMOTS® sampling, conducted within Gloucester and Salem Harbors as part of this project, revealed general habitat conditions within or proximal to various disposal sites within the ZSF, including the vicinity of the preferred G-Cell sites. The REMOTS® sampling survey did not identify or quantify the species of benthic fauna in Gloucester, rather, it provided evidence on the ecological roles of the present species, so that conclusions on community structure could be made (Refer to Section 5.3.2.2 - Benthic Habitat Conditions). Site specific benthic invertebrate sampling will be conducted within the preferred G-Cell sites and this information will be included in the FEIR.

Based on information obtained from Mass GIS databases and information collected from ancillary studies for this project (e.g: habitat characterization via REMOTS® sediment profile imaging, early benthic phase lobster survey, etc.), various economically important benthic invertebrate species are expected to occur extensively within Gloucester Harbor and, therefore, warrant attention for potential environmental impacts associated with UDM disposal in Gloucester Harbor (Table 5-4).

Table 5-4. Important Invertebrate Species of Economic Importance Warranting Attention in Gloucester Harbor from UDM Disposal Impacts

COMMON NAME	*SCIENTIFIC NAME*
American lobster	*Homarus americanus*
Rock crab	*Cancer irroratus*
Blue mussel	*Mytilus edulis*
Soft-shelled Clam	*Mya arenaria*

The results of previous benthic invertebrate studies conducted in nearby Salem Harbor indicate that duck clams (*Macoma balthica*), blue mussels (*Mytilus edulis*), clam worms (*Nereis virens*), various amphipods, and the bivalve, *Nucula delphinodonta*, are dominant benthic invertebrates within Salem Harbor. The periwinkle, *Littorina littorea,* was found to be a dominant intertidal gastropod. A similar community is expected within Gloucester Harbor since the two harbors lie within the same faunal region (boreal zone) and since they share similar geomorphology in many areas (e.g.: fine-grained sediments overlying bedrock substrate, areas of cobble beach and rocky headlands, etc.). However, the Gloucester Inner Harbor is expected to be relatively less diverse (i.e. lower species richness and lower evenness) compared to the Outer Harbor due to the presence of hypoxic conditions which result in azoic areas within some portions of the Inner Harbor.

5.3.2.4 Commercially and Recreationally Harvestable Mollusks

DMF Mapping of Gloucester Harbor Shellfish

According to results presented in the 1994 Annual Report of the Gloucester 301(h) Monitoring Program, the benthic invertebrate community off the mouth of Gloucester Harbor was significantly more diverse than areas sampled within the harbor which was done in earlier studies. Likewise, the report of the Ocean Quahog Research and Demonstration Project (DMF,1977), concluded that the Gloucester Harbor area and vicinity would not support a commercial quahog fishery. All of Gloucester Harbor waters north of the breakwater are closed to shellfishing (DMF, 1999). However existing shellfish beds may still provide seed for cleaner areas, or could become fishable areas if pollutant concentrations were to be reduced in the future.

Various shellfish habitat and nursery areas of Gloucester Harbor and vicinity have been delineated on a map by DMF fisheries biologists and the Gloucester Shellfish Constable (Figure 5-11). It is important to note that these are merely general estimates of areas that have been anectdotally reported as supported shellfish. Shellfish sampling, identification and mapping was not performed as part of the DMMP. The areas depicted in Figure 5-11 support blue mussels (*Mytilus edulis*), and soft shell clams. Blue mussels are found on the benthic substrate just offshore of Pavillion Beach within the Western Harbor, and on rocky shores at several locations around the Main Harbor area, including the rocky coast areas of Mussel Point, Dolliver Neck, Stage Head,

Rocky Neck, and around Lighthouse Cove. Ocean quahogs lie in an extensive area outside the Main Harbor, approximately 3,070 feet (935.7 meters) southeast of Eastern Point. The shallow intertidal flats of Freshwater Cove (landward of Dolliver Neck), Wonson Cove, and Lighthouse Cove contain extensive soft shell clam beds and habitat. The two shellfish species identified from literature review as potentially supporting a future fishery within Gloucester Harbor include blue mussel and softshell clam.

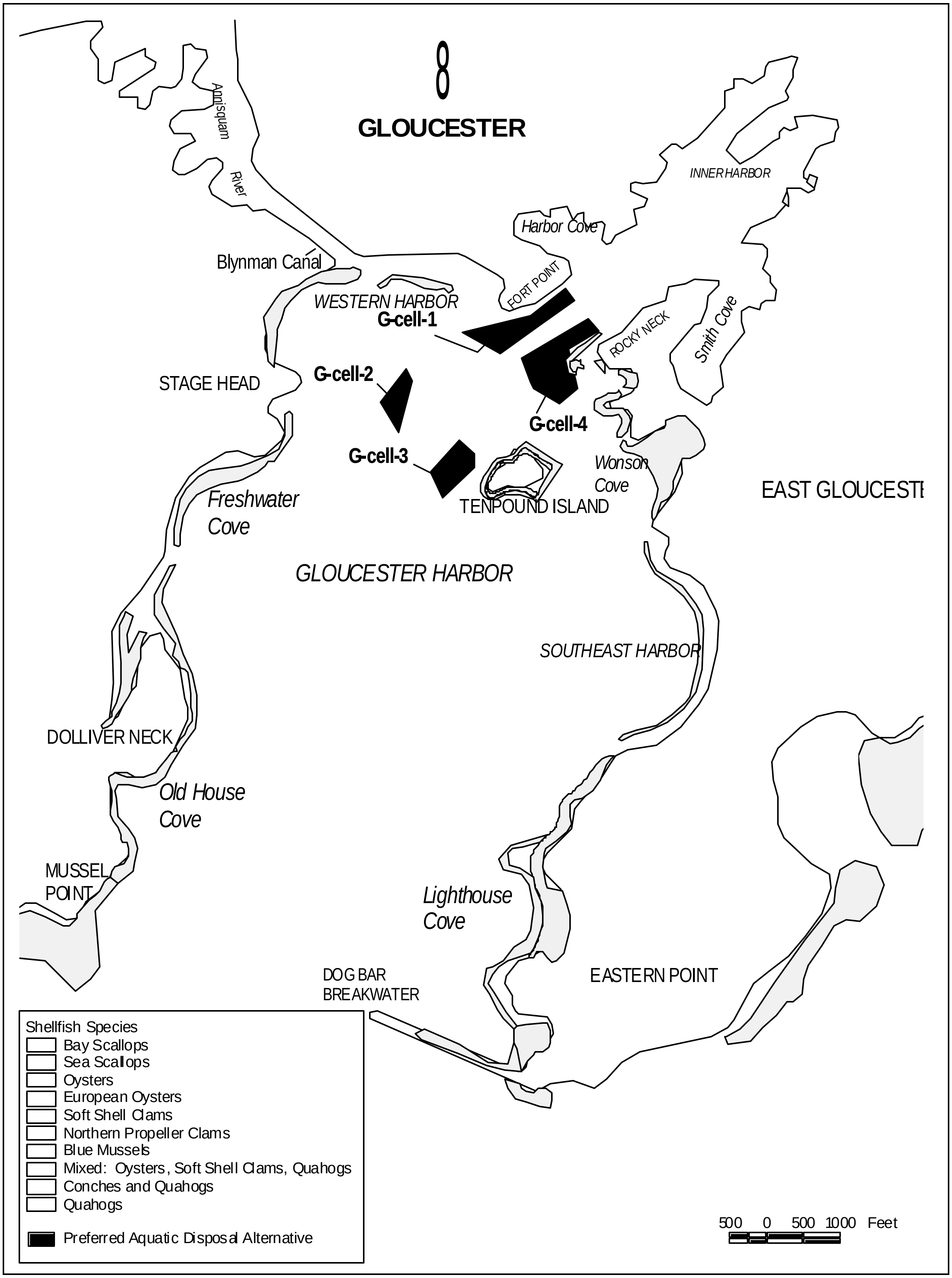

Figure 5-11: Shellfish Resources in the Vicinity of the Preferred Disposal Sites

Other Surveys

Cancer crabs were frequently encountered while transect sampling for early benthic phase lobsters within the main harbor and at the mouth of the Inner Harbor. The two most common species of *Cancer* crabs frequently encountered in the nearshore waters of Cape Ann include the Common Rock Crab, *Cancer irroratus* and the Jonah Crab, *Cancer borealis* (Robbins and Yentsch, 1973).

The results of the REMOTS® sampling did not identify benthic invertebrates to species level but did identify the successional stage of the benthic community. Within the area of the G-Cell sites, REMOTS® sampling stations consistently revealed Stage I marine polychaete concentrations atop sediment bearing characteristic markings of Stage III benthic infaunal invertebrates (refer to Section 5.3.2.2). Certain marine bivalves are part of the Stage III successional community.

5.2.3.5 Lobsters

Both the whole Cape Ann area (including Gloucester Harbor) and the Beverly-Salem area were cited by Jerome *et al*. (1967, 1969) as areas which were very productive and extensively fished for lobsters and very productive. However, specific locations within these areas were cited as being especially productive for lobsters. The DMF has conducted a commercial lobster trap sampling program since 1981, breaking down statistics by six areas in Massachusetts, including Cape Ann (which includes Gloucester) and Beverly-Salem (Estrella and Glenn 1998). The catch per unit effort (per trap per 3-day set) for marketable lobster was 1.11 at Cape Ann and 0.419 in Beverly-Salem in 1997, compared to 0.776 for the state as a whole. Marketable lobsters include all those of 82.6 mm carapace length (CL) or greater and without eggs. The statistics indicate that there is heavy fishing pressure for lobsters in the Beverly-Salem area, probably more than elsewhere in the state. One index of fishing pressure is the percent of the legal catch composed of new recruits, i.e. lobster which reached legal size during their most recent molt. Beverly-Salem leads the six state areas in this statistic, with 96 percent, compared to 88 percent for Cape Ann and 86 percent for the state as a whole, indicating that very few lobsters escape being trapped as soon as they reach legal size. Other indicators of fishing pressure in which Beverly-Salem leads the state are instantaneous fishing mortality, which is the proportion of all deaths that are attributable to fishing, and the exploitation rate, the fraction of the population removed by fishing. Cape Ann is close to or just above the state average in these statistics.

The lobster resources within Gloucester Harbor were sampled by monitoring the catch of a commercial fisherman over the course of one fishing season (NAI, 1999). Lobster trawls consisting of 5 to 20 baited traps were set in Gloucester Harbor (Figure 5-12). Approximately 150 traps were set in each sampling event. One trawl was set in the inner Gloucester Harbor and the remaining trawls were set in the outer harbor during each sampling event. Lobster were measured by carapace length (CL) to the nearest millimeter (mm). Observations of sex, reproductive condition, molt condition, presence or absence of claws, sub-legal (less than or equal to 82 mm)or legal (83 mm or greater) sizing and any pathology present. Trap set period was for three days.

The Inner Harbor CTH_3 was relatively consistent from June through September, and then decreased in October through November and was again low in May. Both legal and sublegal-size lobsters followed the same general month pattern as total CTH_3 (Figure 5-13).

Lobsters caught in the trawl samples, at all sampling stations (GT1 through GT4), were highest in September (Figure 5-14). The numbers then decreased rapidly in October and November. No lobsters were caught in December through March, and CPUE began to increase in April and May. Each of the four trawl stations showed similar patterns of monthly abundance, with catch per haul relatively high in June through November, low catches from December through March, and slight increases in April and May.

In general, Inner Gloucester Harbor area is twice as productive as the Outer Harbor area, primarily due to the high catches of legal-size lobsters in the Inner Harbor. Annual CTH_3 of sublegal lobsters was identical in the Inner and Outer Harbors. The presence of high numbers of legal-size lobster may be due, in part, to the fact that lobstering is not allowed there. The area from approximately Fort Point/Rock Neck inward is closed to lobstering (Figure 5-12).

Early Benthic Phase (EBP) Lobsters

Data and information on EBP lobsters, defined as those with a carapace length (CL) of from 5 to 40 mm, were collected in November 1999 by SCUBA divers swimming along transects within potential disposal site areas. The main objective of the survey was to investigate soft sediments (silt, mud, etc.) for the presence of EBP lobsters, which are highly shelter dependent and may indicate areas of settlement habitat. Additional information was noted, such as number and diameter of burrows, substrate type, and species present (NAI, 1999).

Figure 5-12 shows the survey transects for the EBP survey. Transects 15, 18, 19 were within the footprint of G-Cell sites 1 and 4. Transects 22-27 and Transect 23-28 were within the footprint of G-Cell sites 2 and 3 as a result of transect sampling. No EBP lobsters or EBP lobster habitat were found within the sample area. However during sampling efforts for EBP, evidence was noted which suggests the Inner Harbor and Outer Harbor are suitable for juvenile and adult lobsters. For example at Transect 15, 79 out of 219 burrows (36%) found along a 400m transect were occupied by juvenile or adult lobsters. Urchins and *Cancer* crabs were also noted along this transect. Abandoned (ghost) lobster traps, a gill net, and other debris were also noted along T-15. At T-18, 41 out of 54 (76%) burrows encountered along a 350m transect length were found to be occupied by juvenile or adult lobsters. Hermit crabs and *Cancer* crabs were also noted along the transect, as were ghost traps. At T-19, 54 out of 88 (61%) of the burrows encountered along a 350m transect were found to be occupied by juvenile or adult lobsters. Green and *Cancer* crabs were also noted as were a seastar and a cunner. At T-22-27, 41 out of 101 (40%) of the burrows encountered along a 550m transect were found to be occupied by juvenile or adult lobsters. Green and *Cancer* crabs were also noted. At T-23-28, 45 out of 137 (33%) of the burrows encountered along a 500m transect were found to be occupied by juvenile or adult lobsters. Green and *Cancer* crabs were also noted. This was the only transect in which mussels (probably the inedible horse mussel, *Modiolus modiolus*) and kelp (*Laminaria* sp.) were noted.

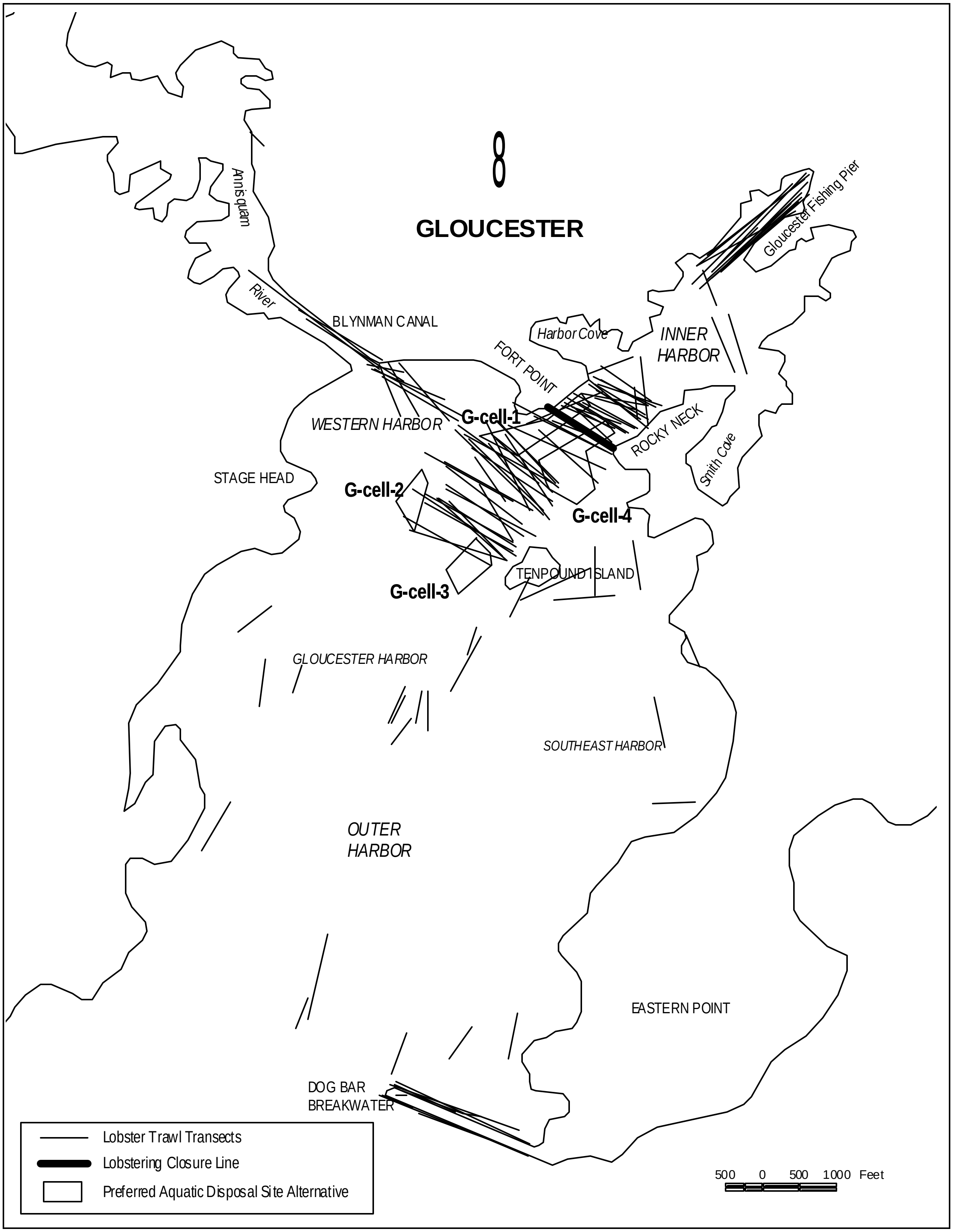

Figure 5-12: Lobster Trawl Transects in Gloucester Harbor, 1998-1999. (NAI, 1999)

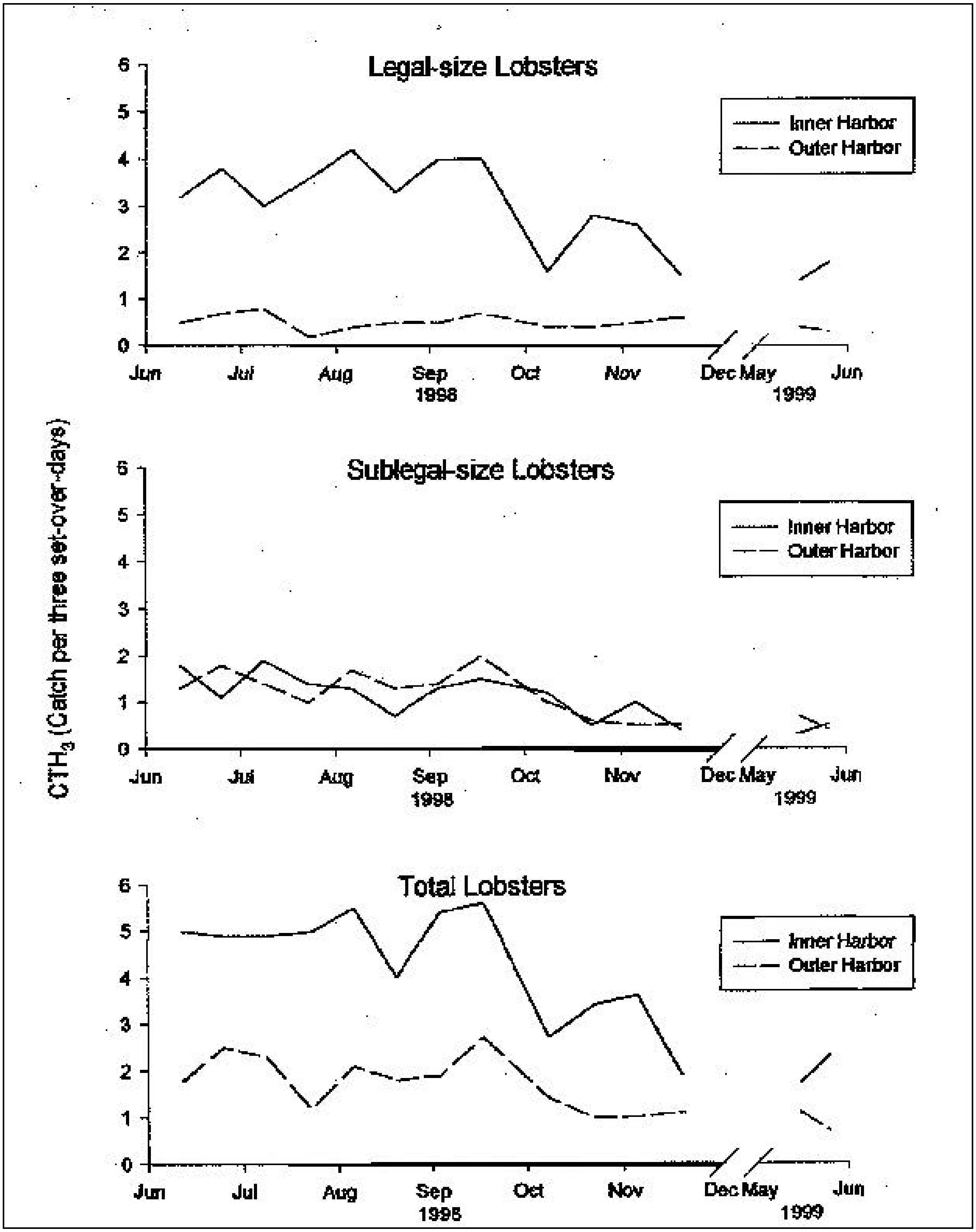

Figure 5-13: Catch per Three Set-Over-Days (CTH_3) for Lobsters in Inner and Outer Gloucester Harbor from Lobster Sea Sampling, June Through November 1998 and May 1999.
(Normandeau, 1999)

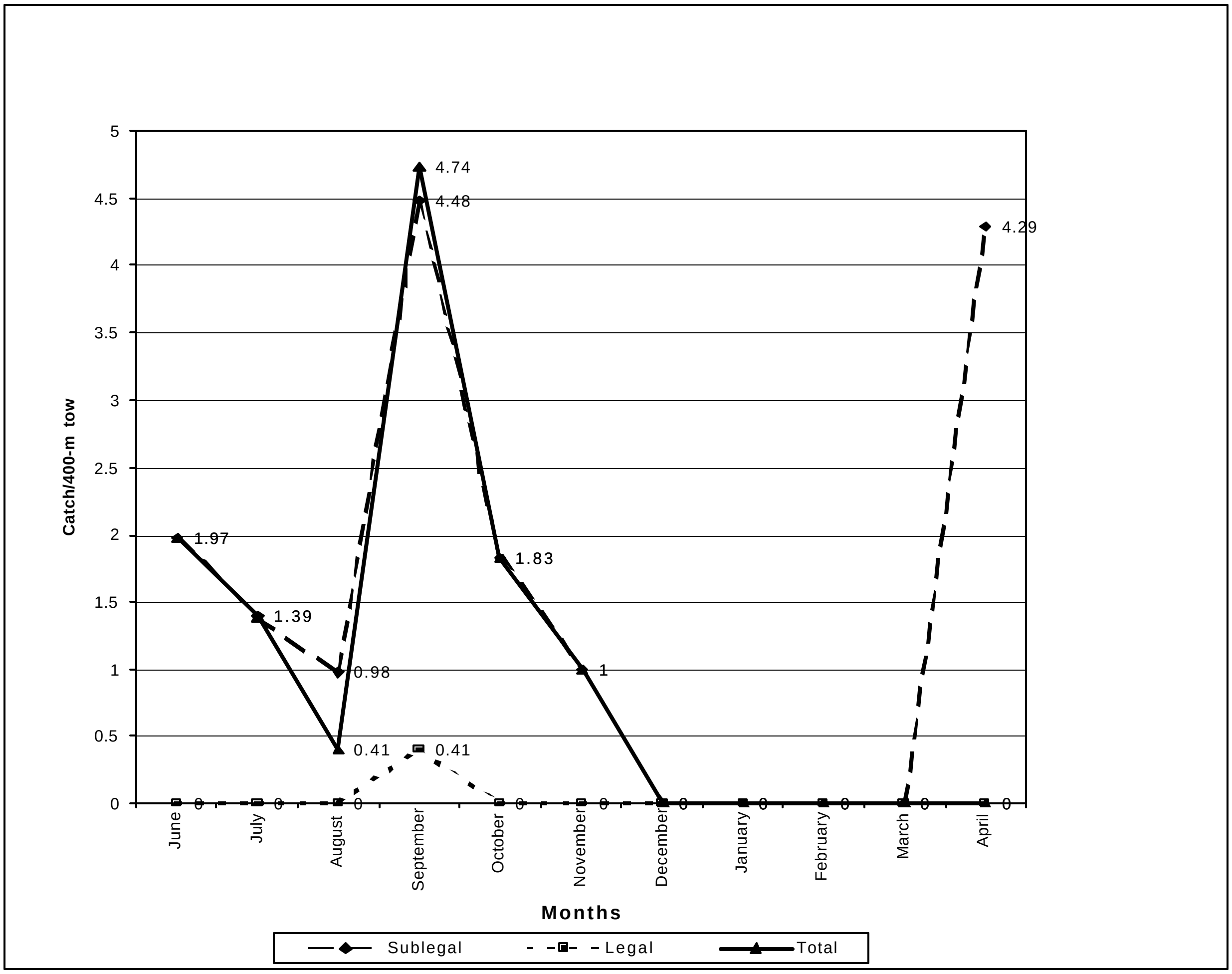

Figure 5-14: Catch Per Unit Effort of American Lobster in Gloucester from Otter Trawl Sampling, June 1998 Through May 1999 (Normandeau, 1999)

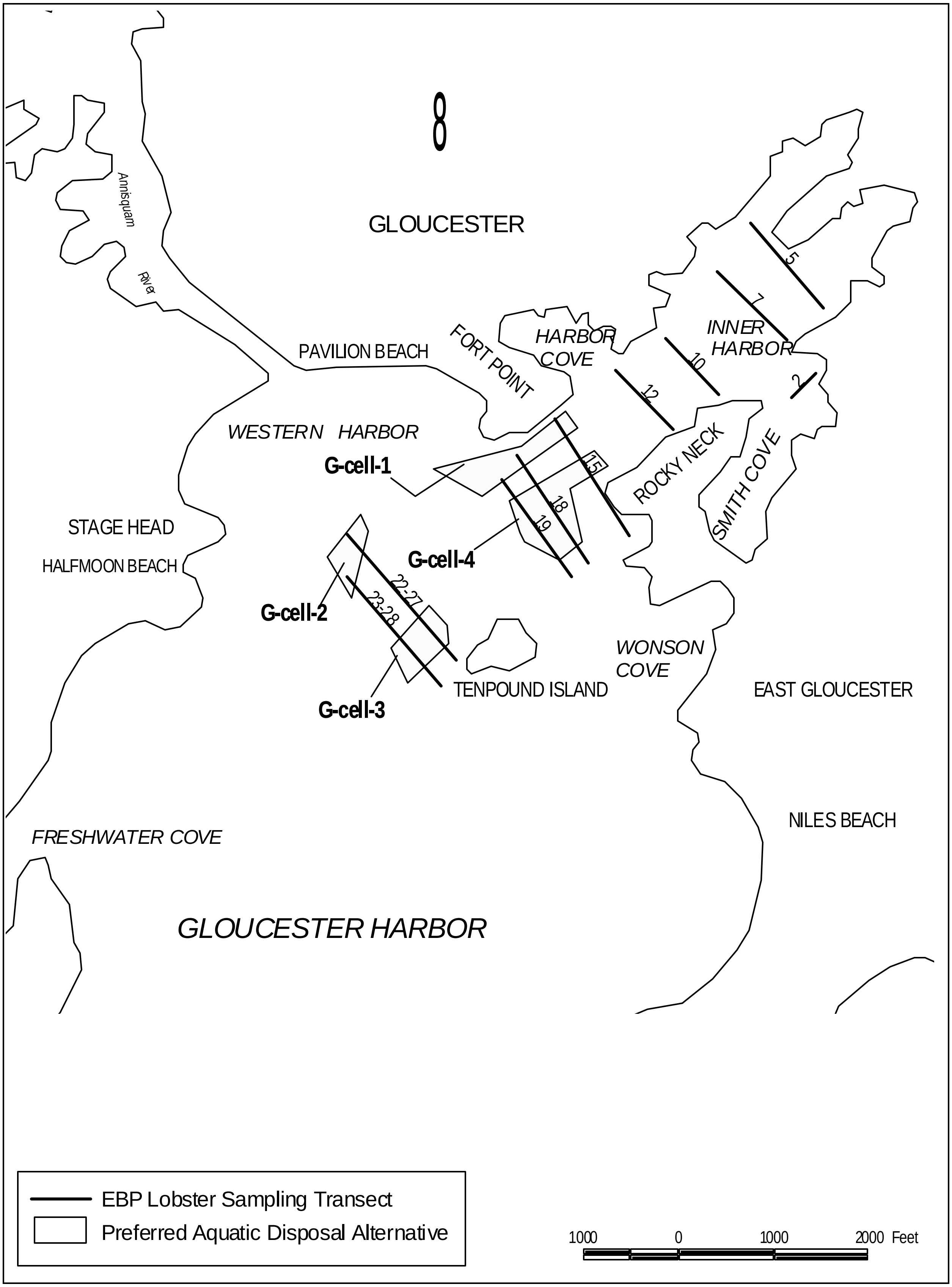

Figure 5-15: EBP Transects and Gloucester Sites (Normandeau, 1999)

Results of the transect sampling for early benthic phase lobster revealed that surficial sediments along transects across the channel and vicinity were primarily composed of soft silt / mud. Since no EBP were found within the inner harbor and northeastern portions of the Gloucester Main Harbor, these areas may not provide suitable habitat for early benthic phase lobsters. However, these areas of Gloucester Harbor appear to provide sufficient habitat to support juvenile and adult lobsters as well as other forms of benthic invertebrates. Transect T-15 had the highest relative index of lobster abundance (i.e. the greatest number of lobsters / linear meter).

5.3.3 Finfish

Because of the mobility of fish, the characterization of fish species within a specific area, such as the G-Cell sites is difficult. However, several studies give insight into the types, patterns, and behavior of the dominant fish species in the North Shore region and Gloucester Harbor, in particular. This information, coupled with what is known about environmental conditions at the G-Cell sites (e.g. substrate type, water quality, water depth), allows for a reasonable characterization of finfish at and near the preferred aquatic disposal sites.

This Section discusses the following aspects of finfish activity in the North Shore Region and Gloucester Harbor:

- Essential Fish Habitat (EFH) Listings for Gloucester Harbor;
- Summary of Gloucester Harbor boat trawl and beach seine survey data (June 1998 - May 1999)
- Summary of Salem Sound Resource Assessment trawl survey by depth strata ;
- Evaluation of nursery potential by site;
- Fish spawning potential;
- Diadromous fish activity; and,
- Commercial and recreational fishing.

Table 5-5 lists the common and scientific names of the fish species discussed in the ensuing sections.

5.3.3.1 Regional Finfish Data (Salem Sound to Cape Ann)

As with the invertebrate fauna, the marine fish of Gloucester are part of the boreal biogeographical region, characterized by colder temperatures and less summer warming, and therefore a smaller annual temperature range, than waters south of Cape Cod (the temperate region). Many northern species of fish reach the southern limit of their range at Cape Cod, and many southern species reach their northern range limit there as well.

The most extensive historic data on fishery resources in the north shore region are from the study conducted by DMF in 1965, which reported on a combination of otter trawls and beach seines in the waters of Beverly, Salem, Danvers, Manchester, and Marblehead. Thirty-one species of finfish were found in the Beverly-Salem area. Several of the sampling stations in the 1965 survey were replicated as part of the SSRAS (Figure 5-16).

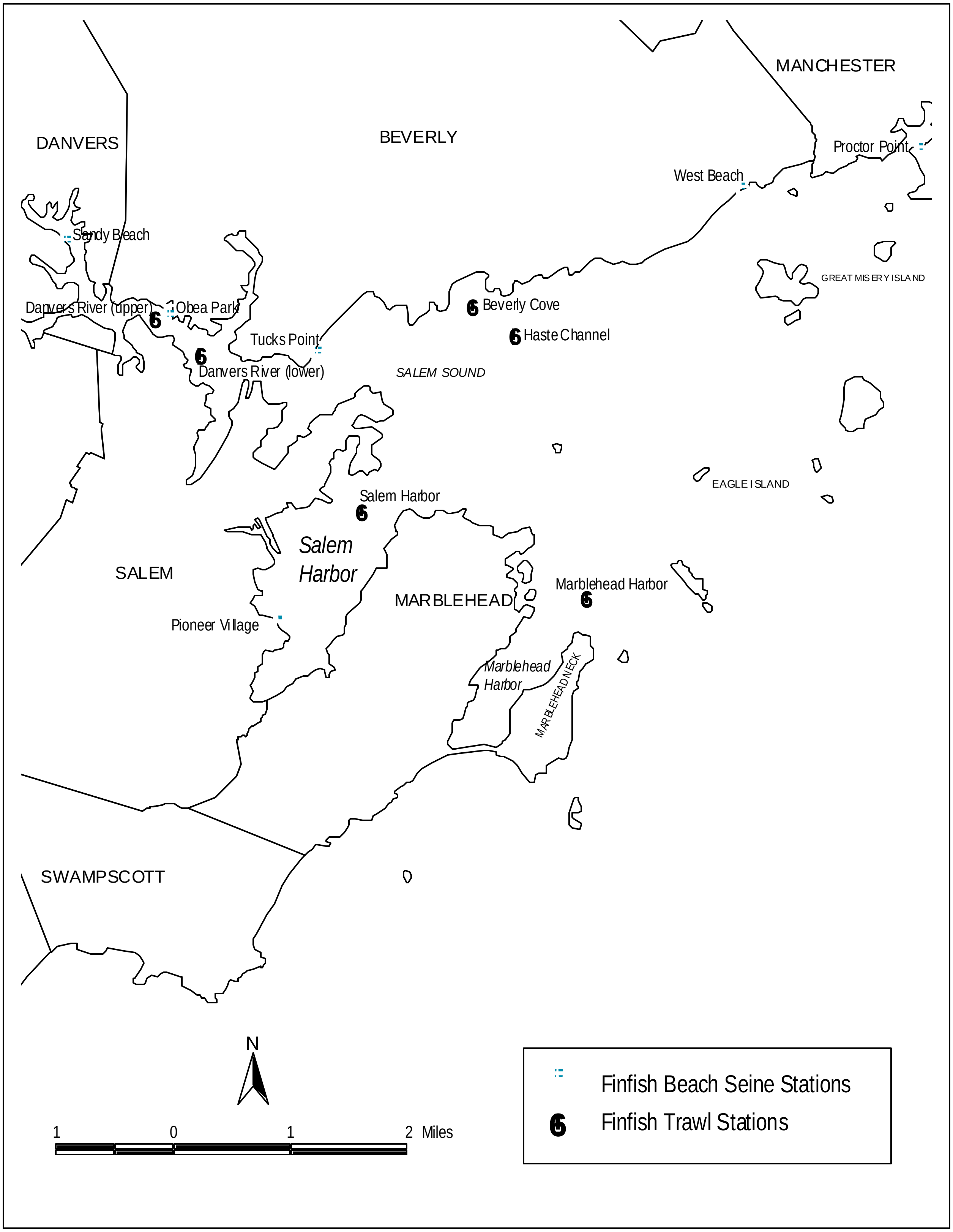

Figure 5-16: Beach Seine and Trawl Surveys in Beverly-Salem Area during January to December, 1997 (Chase, in prep.)

Table 5-5. Common and Scientific Names of Fish Species Discussed in this DEIR

Common Name	Scientific Name
Atlantic silverside	*Menidia menidia*
Atlantic menhaden	*Brevoortia tyrannus*
Atlantic herring	*Clupea harengus*
Winter flounder	*Pseudopleuronectes americanus*
Mummichog	*Fundulus heteroclitus*
Winter flounder	*Pseudopleuronectes americanus*
Skate spp.	*Raja* spp.
Atlantic cod	*Gadus morhua*
Cunner	*Tautogolabrus adspersus*
Windowpane	*Scophthalmus aquosus*
Blueback herring	*Alosa aestivalis*
Lumpfish	*Cyclopterus lumpus*
Pollock	*Pollachius virens*
Rock gunnel	*Pholis gunnellus*
Atlantic mackerel	*Scomber scombrus*
Striped bass	*Morone saxatilis*
Tautog	*Tautoga onitis*
Haddock	*Melanogrammus aeglefinus*
Yellow-tailed flounder	*Limanda ferruginea*
American plaice	*Hippoglossoides platessoides*
Silver hake	*Merluccius bilinearis*
Monk fish	*Lophius americanus*
White hake	*Urophycis regia*
American sand lance	*Ammodytes americanus*
Longhorn sculpin	*Myoxocephalus octodecemspinosus*
Ocean pout	*Marcozoarves americanus*
Northern pipefish	*Syngnathus fuscus*
Northern puffer	*Sphoeroides maculatus*
Grubby	*Myoxocephalus aenaeus*
Bluefish	*Pomatomus saltatrix*

The fish species sampled in 1997, are typical of nearshore environments north of Cape Cod. The most common species sampled by Jerome et al. in 1965 were also common in 1997. For example, the first, second and third ranking species in 1965, (mummichog - *Fundulus heteroclitus*, silverside - *Menidia sp.*, and Atlantic herring - *Clupea harengus*), ranked fifth, first, and third in 1997. A notable difference in the species found between the two years is that menhaden (*Brevoortia tyrannus*), the second most abundant species seined in 1997, was not caught at all in the seine in 1965. Differences in the total species list and in some relative abundances between the two studies maybe due to a result of the patchy distribution typical of many marine fish. This illustrates the limitations of seine sampling. For example, over 96 percent of the menhaden sampled were seined from two stations on a single date in September. At Tucks Point, all but two of the 4,249 individuals sampled were from a September sampling date. It is possible that if that single date had been missed, menhaden would have been regarded as scarce in Salem Sound in 1997, rather that as the second most abundant shore species. The two stations at which the greatest numbers of fish were caught in the seine were Tucks Point at the mouth of the Danvers River in Beverly, and Sandy Beach on the Porter River. These stations were dominated by menhaden and silverside, respectively, although other species were also caught. The lowest numbers of fish throughout the 1997, survey were collected at West Beach, the only station exposed to the open ocean and therefore exposed to greater wave action than the others. In 1965 at West Beach, no fish at all were seined in 8 of the 12 months in which sampling took place, and if it were not for a single haul in May of 236 Atlantic herring, West Beach would have been the least productive station in 1997, as well. The station with the lowest seine catch in 1965 was Tucks Point, which was the most productive in 1997. The station with the highest seine catch in 1965 was Proctor Point, due mainly to a large number of mummichogs on a single date. These results further illustrate the variable nature of seine sampling. Although seine catches may be largely influenced by single catches of single species; the seine data is a good indication of the seasonality of fish abundance.

The most consistent result noted was the low numbers from the West Beach sampling station, which indicated that high-energy beaches have relatively few nearshore fishes, or the seine is inefficient at collecting nearshore fishes. In the trawl samples, 34 species were caught, with the most abundant species being winter flounder, followed by skates (*Raja* spp.), Atlantic cod (*Gadus Morhua*), and cunner (*Tautogolabrus adspersus*). Table 5-6 indicates the most common species sampled in the trawls, comprising over 76 percent of individuals caught.

The most noticeable differences between the samples taken in 1965, and those taken in 1997, are the decrease in dominance by winter flounder, from 84 percent of individuals sampled in 1965, to 32 percent in 1997, and the appearance of large numbers of skates in the samples, which had been a very minor part of the catch (only eight individuals all year) in 1965. Also, yellowtail flounder had been the third most common species at the deeper stations in 1965, but was represented by only two individuals in 1997. Haddock, fourth most common in 1965, was absent in 1997. Skate have become a more common part of the local demersal fish fauna in recent years, and this is reflected in the 1997 samples.

Table 5-6: Five Most Abundant Fish Species Collected (Total No.) in Nearby Salem Sound Beach Seine Survey, 1997 (Massachusetts Division of Marine Fisheries unpublished data).

Common Name	ScientificName	Obea Park	Pioneer Village	Proctor Point	Sandy Beach	Tucks Point	West Beach	All Stations
Atlantic silverside	*Menidia menidia*	2,201	2,449	718	4,438	218	232	10,256
Atlantic menhaden	*Brevoortia tyrannus*	7	95	1,397	6	4,249	--	5,754
Atlantic herring	*Clupea harengus*	1	--	--	390	1,708	49	2,148
winter flounder	*Pseudopleuronectes americanus*	20	40	45	264	526	33	928
mummichog	*Fundulus heteroclitus*	80	61	15	238	2	--	396
all other species								345

Table 5-7: Five Most Abundant Species Collected (Total No.) in Salem Sound Trawl Survey (Massachusetts Division of Marine Fisheries unpublished data)

Common name	Scientific name	Beverly Cove	Danvers River	Haste Channel	Marblehead Harbor	Salem Harbor	All Stations
winter flounder	*Pleuronectes americanus*	68	197	256	98	451	1070
skate spp.	*Raja* spp.	65	59	181	45	293	643
Atlantic cod	*Gadus morhua*	32	15	112	71	123	353
cunner	*Tautogolabrus adspersus*	240	34	19	22	25	340
windowpane	*Scophthalmus aquosus*	7	--	73	4	70	154
Total of 29 other species							792

Note: values in table are numbers of individuals

5.3.3.2 Gloucester Finfish Data

Essential Fish Habitat (EFH)

Under the Magnuson-Stevens Fishery Conservation and Management Act, a.k.a. the Sustainable Fisheries Act (SFA), an EFH is broadly defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". All of Gloucester Harbor is within a designated EFH for 30 species listed in the SFA.

Diadromous Fish Activity

Four species (alewife, American shad, blueback herring, rainbow smelt) of diadromous fishes inhabit the north shore area, although it is not known if any diadromous fish runs occur within Gloucester Harbor. Diadromous fish are those that, at any particular life stage, regularly move between freshwater and saltwater, spending part of their life cycle in each environment. Blueback herring were found during the months of June and July within Gloucester Harbor during a recent beach seine sampling survey conducted in the harbor for finfish (NAI, 1999). Many fish within the sample contained individuals that were between 55 and 92 mm long, which are considered to be young of the year (YOY) (Mullen et al, 1986). This suggests that blueback herring may run the Annisquam River and its tributaries.

Summary of Seine and Trawl Surveys

Seine and trawl sampling was conducted for fisheries and lobsters, consistent with previous studies (i.e. Jerome et. al., 1969), in Gloucester Harbor from June 1998 through May 1999 in support of proposed dredging activities. The purpose of the sampling was to provide data that can be used to evaluate the effects of dredging and aquatic disposal on fisheries resources. All sample locations were recorded by differential GPS (Global Positioning System). Fish sampling occurred twice per month at four nearshore locations and four deeper water locations , within Gloucester Harbor. This sampling was conducted June through October 1998 and in May 1999, while once per month in November 1998 through April 1999.

For each seine and trawl sample, all fish were identified to species, counted and measured for total length to the nearest mm, and biomass in grams. Exceptionally large catches were estimated through volumetric sub-sampling, in which a minimum of twenty fish were measured. Ages of the fish were estimated based on their lengths. Descriptive statistics (mean, range and percent composition) were used to characterize trawl and seine stations. Temporal and spatial features of the juvenile fish community are described for Gloucester Harbor.

The locations of each Seine and Trawl station are depicted in Figure 5-17. The sampling protocol and results for each sampling method are described in their respective sub-sections below.

Seine Survey

Nearshore sampling locations consisted of a 50-foot seine with a 3/16 delta mesh, positioned parallel to shore in approximately 1 m of water and then directly hauled to shore covering a rectangular area. The resources were calculated as a Catch Per Unit Effort (CPUE) based on the number of fish per haul.

Seine catches in Gloucester harbor were dominated by large catches of a few species. On several sampling dates no fishes were caught. The most numerous fish captured by the seine was Atlantic Silversides (*Menidia menidia*), accounting for 43 % of the total catch at all seine sampling locations. Winter flounder comprised 8%, lumpfish (*Cyclopterus lumpus*), blueback herring, and mummichog all comprised of 6 % of the fishes captured in nearshore Gloucester Harbor (Table 5-8).

Four nearshore sampling stations, identified as GS1 through GS4, were regularly sampled in Gloucester Harbor seine survey. Sampling station GS1 was located at Pavillion Beach, GS2 at the northeast side of Ten Pound Island, GS3 near Halfmoon Beach and GS4 at Niles Beach (Figure 5-14).

CPUE of Atlantic silversides generally rose throughout the summer to a peak in abundance in September and October (Figure 5-18), primarily due to an increase in the capture of Atlantic silversides, mostly Young of Year (YOY, annual fry) fish. The lowest CPUE was observed from November through March and began to increase thereafter. Winter flounder, which ranked second in CPUE, was highest in September. Most of the captured comprised of YOY fish (less than 100 mm). Sampling events in January through April decreased to zero, due to the fish moving to deeper water. Lumpfish ranked third in overall CPUE and were primarily captured during one sampling event (September 2) when large amounts of debris was observed in the haul. Based on the captured fish length, most of the sample was comprised of YOY fish. Blueback herring were recorded at sample stations GS2 and GS3 in June and July. Largely the sample contained fish that were between 55 and 92 mm long, considered to be YOY (Mullen et al, 1986). Mummichog were present in August, October and November, primarily at sampling station GS3 at lengths less than 60 mm. Other fish observed in the sample catches were windowpane, Atlantic menhaden, northern pipefish (*Syngnathus fuscus*), northern puffer (*Sphoeroides maculatus*) and grubby (*Myoxocephalus aenaeus*). Seine sampling revealed that fish species total abundance and diversity was generally greatest in the late summer and early fall months.

Trawl Surveys

Deeper water sampling was conducted with a 30-foot trawl made of 2-inch stretch mesh in the body and 1-inch stretch mesh in the cod end with a 1/4-inch liner. Each trawl was towed for approximately 400 m. When a 400 m tow length was not achieved, the length and catch was standardized by the following mathematical equation.

$CPUE_{s,t} = (CATCH_{s,t}/TOW_t)\ 400$

where,

$CPUE_{s,t}$ = Catch per unit effort for species S in Sample T
$CATCH_{s,t}$ = Catch of species S in sample T
TOW_t = Tow length in m of sample T

The trawl catches characterized the fish community of depths from 18 to 36 feet, within Gloucester Harbor. Trawl sampling locations are identified as GT1 through GT4 as shown in Figure 5-14. Sampling location GT1 was located in Southeast Harbor at a depth of 30 to 36 feet (9 to 11 meters). Station GT2 was located in the outer Gloucester Harbor at a depth of 29-35 feet (8.8 to 10.7 meters). Sampling station GT3 was located at the entrance to Blynman Canal at depths ranging from 18 to 25 feet (5.5 to 7.6 meters). Lastly, sampling station GT4 was located in the Inner Harbor near the entrance to the North Channel at depths between 25 and 28 feet (7.6 to 8.5 meters).

Catches were numerically dominated by winter flounder representing 27 % of CPUE, skates (*Rajaformes*), 20 %, Atlantic cod 12%, and both red hake and rock gunnel (*Pholis gunnellus*) 7 %. The skate species were grouped into one category due to the difficulty in field identification. Skates ranked first in biomass.

Monthly CPUE was relatively consistent from June through November, and then decreased during December through February as water temperatures decreased and the fish moved to deeper water (Figure 5-19). On average monthly CPUE began to increase in March and reached the highest levels in April and May. Winter flounder and Atlantic cod contributed to the high CPUE in April and high catches of cod and skates resulted in the high CPUE in May. The fifth most abundant fish captured in Gloucester Harbor, rock gunnel, was observed in every month except August and January.

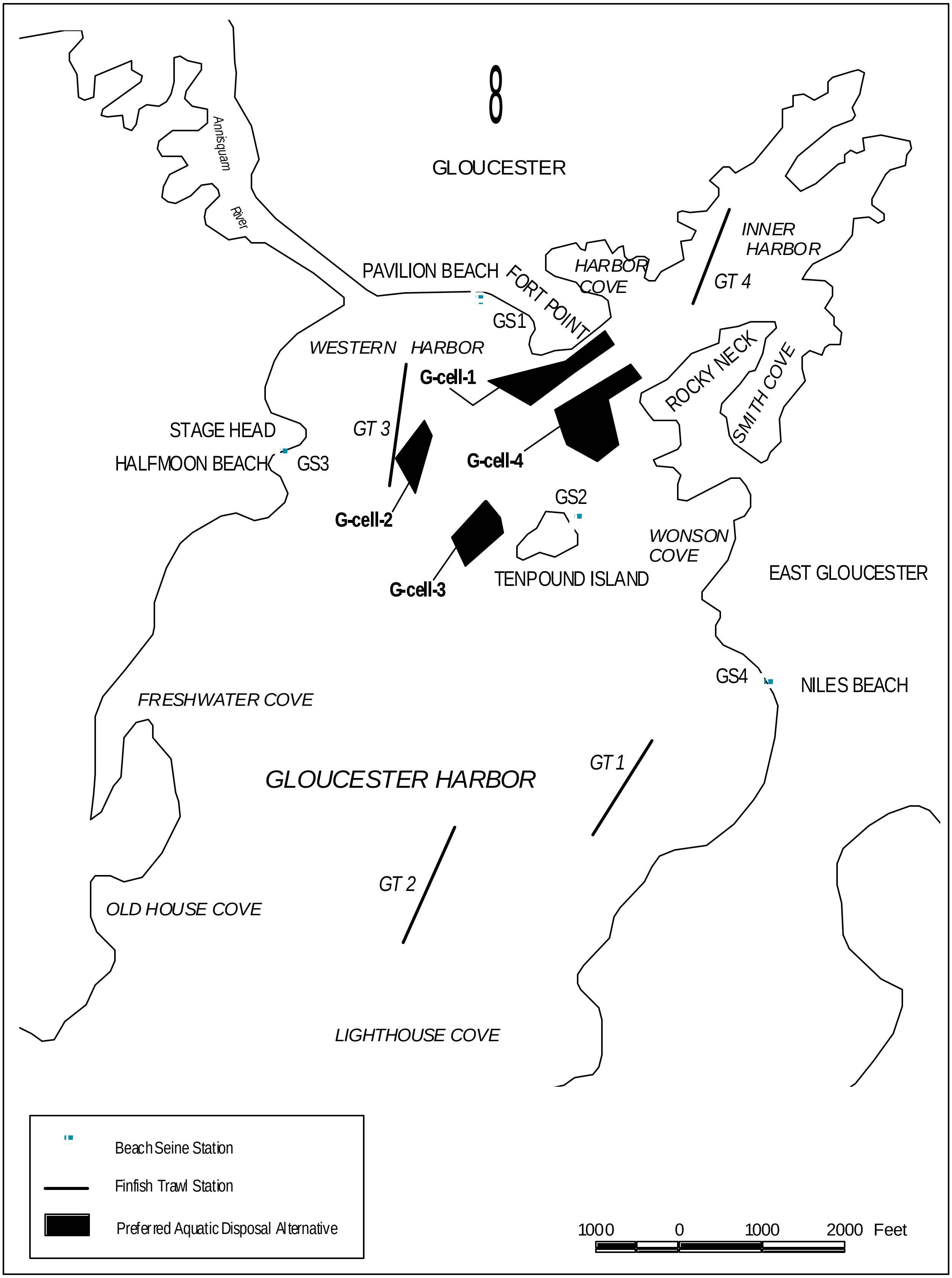

Figure 5-17: Beach Seine and Trawl Station Locations in Gloucester Harbor (Normandeau, 1999)

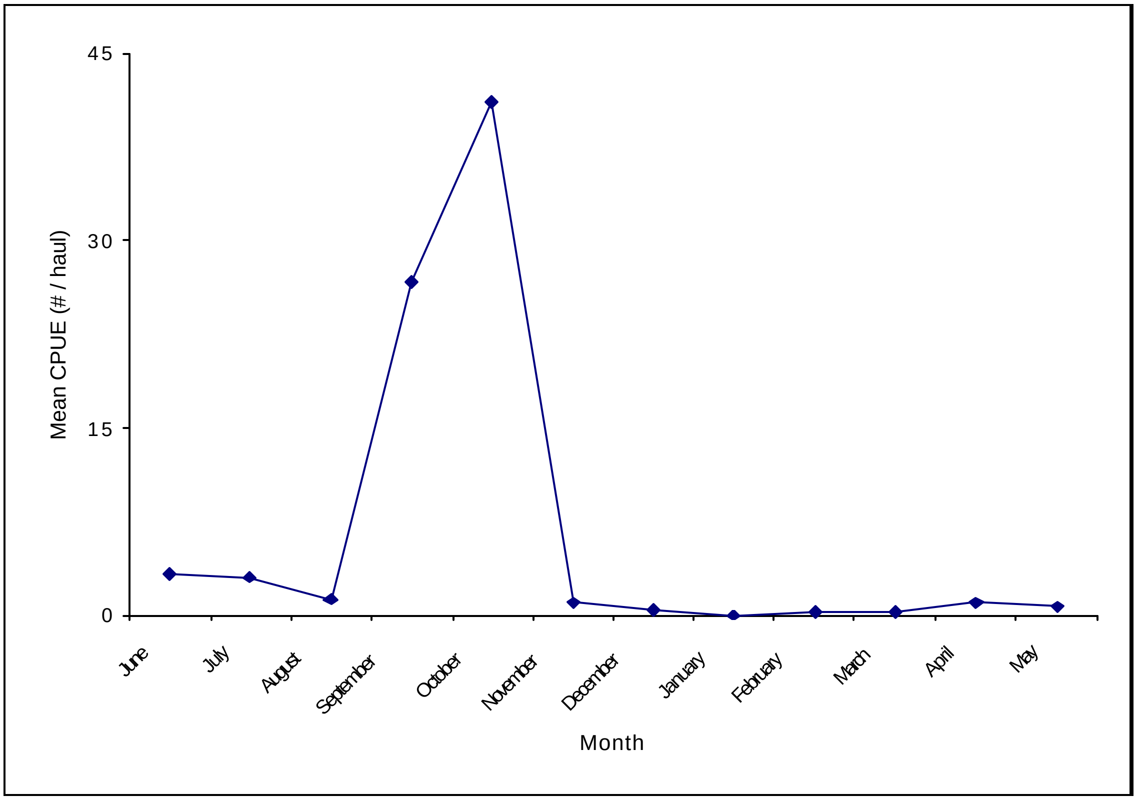

Figure 5-18: Total mean catch per unit effort (CPUE= #/haul) for Gloucester Harbor beach seine stations, June 1998 to May 1999 (Normandeau, 1999).

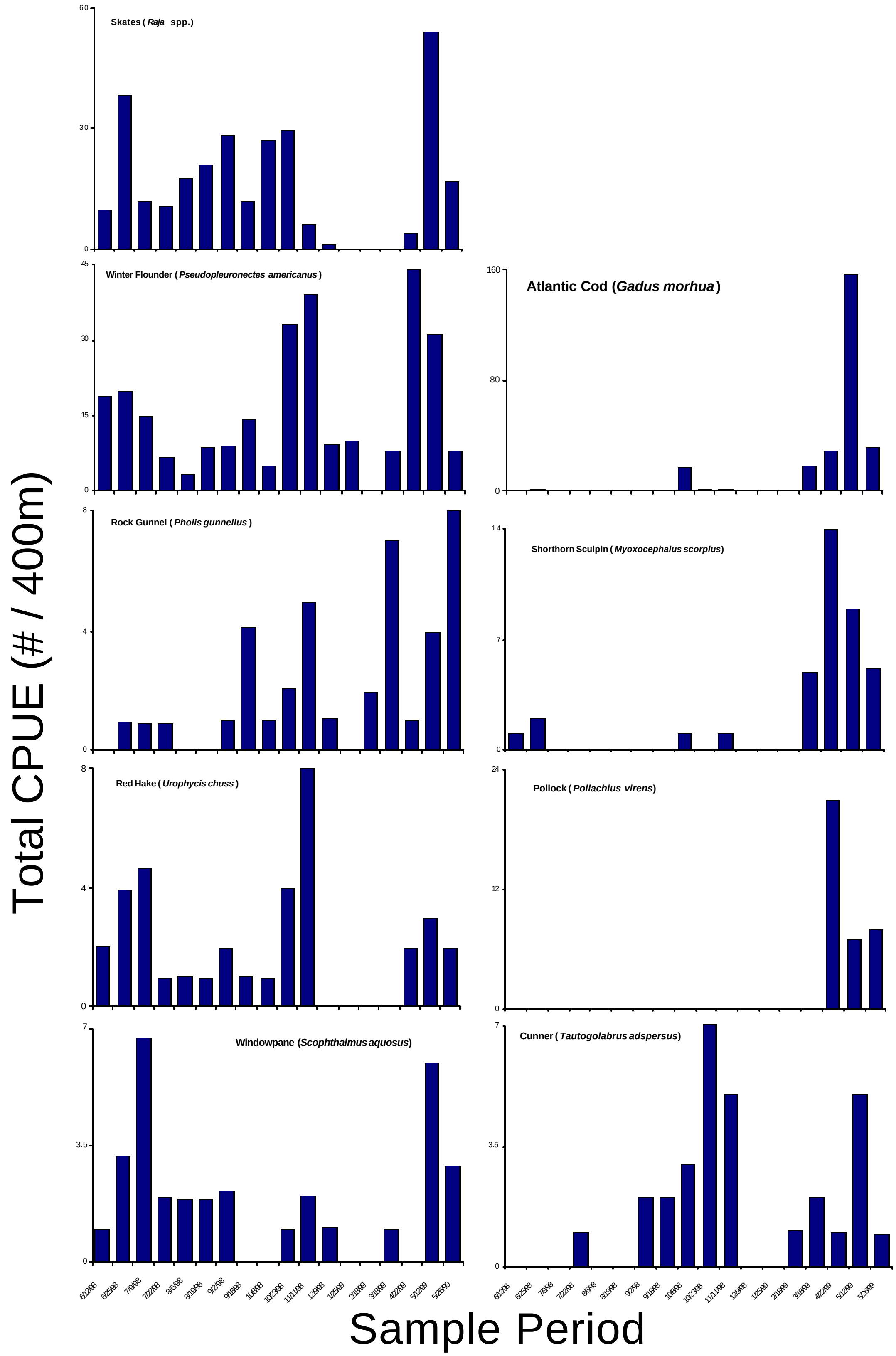

Figure 5-19: Total catch per unit effort (CPUE - #/400m) for all Gloucester Harbor otter trawl stations combined of selected fish species, June 1998 to May 1999 (Normandeau, 1999)

Note: *Different CPUE scales*

Table 5-8. Percent of fish caught in seine samples taken in Gloucester Harbor from June 1998 through May 1999 (geometric mean catch per trawl).

Species	Station GS1 %	Station GS2 %	Station GS3 %	Station GS4 %	All Stations Combined (GS1-4) %
Atlantic Silverside	56	15	36	56	43
Blueback herring	N	17	7	N	6
Lumpfish	N	N	12	N	6
Mummichog	6	N	8	N	6
Winter flounder	9	N	9	N	8
Northern pipefish	6	12	N	9	0
Windowpane flounder	11	N	N	N	0
Cunner	N	12	N	N	0
Grubby	N	15	N	14	0
Other species	11	30	28	6	31
Total	99	101	100	100	100

Notes: N = negligible. Some totals do not equal 100% because of rounding
Source: Normandeau, 1999

Table 5-9. Percent of fish caught in trawl samples taken in Gloucester Harbor from June 1998 through May 1999.

Species	Station GT1 %	Station GT2 %	Station GT3 %	Station GT4 %
Atlantic Cod	9	16	12	11
Pollock	8	N	N	N
Skate sp.	19	11	27	16
Rock gunnel	14	N	N	N
Winter flounder	24	28	24	29
Cunner	N	10	N	N
Shorthorn sculpin	N	8	N	9
Windowpane flounder	N	N	7	N
Red hake	N	N	9	N
Rainbow smelt	N	N	N	8
Other species	26	27	20	29
Total	100	100	99	100

Notes: N = negligible. Some totals do not equal 100% because of rounding
Source: Normandeau, 1999

Nursery Potential

Utilizing the information from the EBP lobster survey (SCUBA observations), DMMP Seine and Trawl Surveys, REMOTS® survey, and other literature, the potential value for the Preferred Aquatic Disposal Sites as a nursery for finfish and large invertebrates was assessed. UDM disposal is more likely to affect sensitive larval and juvenile stages of fish and invertebrates, so the protection of areas with high nursery potential is important. Nursery potential is estimated using the following empirical formula (Wilbur, 1999):

HABITAT COMPLEXITY + JUVENILE PRESENCE = NURSERY POTENTIAL (HIGH, MODERATE, LOW)

Habitat complexity (1-12) is highest where there is variation in substrate conditions and greatest vertical structure. Juvenile presence (yes/no) is the dominant commercial, recreational and non-target organism collected in substantial numbers or apparent in similar habitat.

All Gloucester Harbor candidate aquatic disposal sites were determined to have moderate to high nursery potential for juvenile fish, namely Atlantic cod, pollock (*Pollachius virens*), and winter flounder. Therefore, the G-Cell sites will also have moderate to high potential for juvenile fish since the G-Cell sites are subsets of the three original candidate aquatic disposal sites within the Inner Harbor. Recent beach seine and open water trawl sampling conducted within Gloucester Harbor (NAI, 1999) revealed winter flounder to be one of the most abundant fish within the harbor in the fall. Most of the winter flounder captured during this recent sampling effort were noted to be young of the year juvenile fish. This suggests that the harbor provides important nursery habitat for this species. Semi-annual inshore trawl surveys from 1978 to 1999 revealed that many eastern Massachusetts coastal embayments are used by juvenile Atlantic cod as settlement and nursery areas. Juvenile cod are brought to these coastal embayments due to prevailing southwestward-flowing coastal currents and off-shore prevailing easterly summer winds which, combined, carry eggs and larvae shoreward (Pierce, 2000).

Spawning Potential

Spawning periods for the most common fish and invertebrates within a given area are commonly used as a model for assessing overall marine fish spawning potential for that area. In fact, dredging is often limited to the times of year of decreased spawning, which is typically winter to spring. Many local surveys have identified important habitat associations (sand and cobble, eelgrass) that appear to be essential for the reproduction and development of fishes and invertebrates. Spawning potential within and proximal to the G-Cell Sites is estimated as "MODERATE" because the sediment there is uniformly soft silt, with little variation and no eelgrass beds are present. The Inner Harbor and proximity is a depositional environment, hence the predominance of soft silt in the surficial sediment.

Based on habitat associations and regional distribution of spawning activity, several species may find suitable environmental conditions for spawning within ports, estuaries and/or open water. Within nearby Salem Harbor, Salem Sound and Massachusetts Bay, there are at least eleven common fish species that spawn. They are: American sand lance (*Ammodytes americanus*), Atlantic cod, cunner, longhorn sculpin (*Myoxocephalus Octodecemspinosus*), northern pipefish, ocean pout (*Macrozoarves americanus)*, red hake, silversides, tautog, windowpane flounder and winter flounder. Gloucester is expected to have a similar community assemblage of spawning fish species, especially winter flounder, since young of the year juveniles were found to dominate catches per unit effort in a recent fall sampling effort (NAI, 1999).

The seasonality of spawning for the dominant fish and invertebrates is an important factor in planning UDM disposal. For instance, dredging and disposal restrictions are imposed by DEP for north shore harbors to protect the spawning activities of the dominant species within that region of Massachusetts coastal waters (see DMF memo in Appendix B). Spawning for most of these organisms occurs in the spring, summer and early fall. As such, dredging has historically been limited to the late fall and winter season to protect spawning activities. The imposition of seasonal restrictions avoids impacts to sensitive eggs and larvae within the water column (pelagic) and on the seafloor (demersal).

Recreational and Commercial Fishing

A series of meetings with local fishermen, both commercial and recreational, were held to discuss the regional fisheries resources of the Gloucester area. At these meetings, they were asked to map the major recreational finfishing, commercial finfishing, and commercial lobstering areas and to denote which months specific species were sought and harvested. Any area with suitable access to the waterfront is a likely recreational area. However, the areas identified for this section were reported to have particular local significance, importance, or popularity.

<u>Recreational Fishing</u>

There is an extensive recreational fishery based in Gloucester Harbor and vicinity (Sartwell, 1997). Striped bass, bluefish, mackerel, tautog and winter flounder are among the principal species sought by recreational fishermen from both nearshore locations and via private boat. The best areas for flounder, reported by Gloucester fisherman and accessible by boat, occur off Niles Beach in the Southeast Harbor and off Doliver Neck on the western side of the Harbor. Local fisherman report that flounder were formerly more abundant, and that it is believed by most local fisherman that the flounder population may have been reduced over the years by overfishing, pollution, or a combination of factors. However, in recent years, with cleanup of the harbor and catch limits, the flounder are recovering (Koutrakis 1997). The other common recreational finfish species can be found in most areas of Gloucester Harbor and vicinity. However, there are certain areas that these species are most frequently fished (Figure 5-20). Some of these areas are fished because of easy boat or land-side access (e.g. Ten Pound Island and the State Pier, respectively), while others are fished because environmental conditions favor aggregation of the species. In either case, recreational fishing is prevalent along Pavillion Beach, Niles Beach, Cressy Beach and the Stage Fort Park area, and from the Dog Bar Breakwater. In contrast to nearshore locations, deep water areas may not be as commonly fished recreationally, not because there are no fish present, but because of greater travel distance from shore. Tautog remain close to submerged structures such as rocks, reefs and ledges. Therefore, they are also not caught in trawls in open water. Table 5-10 lists some of the principal recreationally fished species in the Gloucester Harbor area with notes on habitat from Bigelow and Schroeder (1953). The reported or expected locations of the various recreational fish in Gloucester Harbor are also presented in Table 5-10.

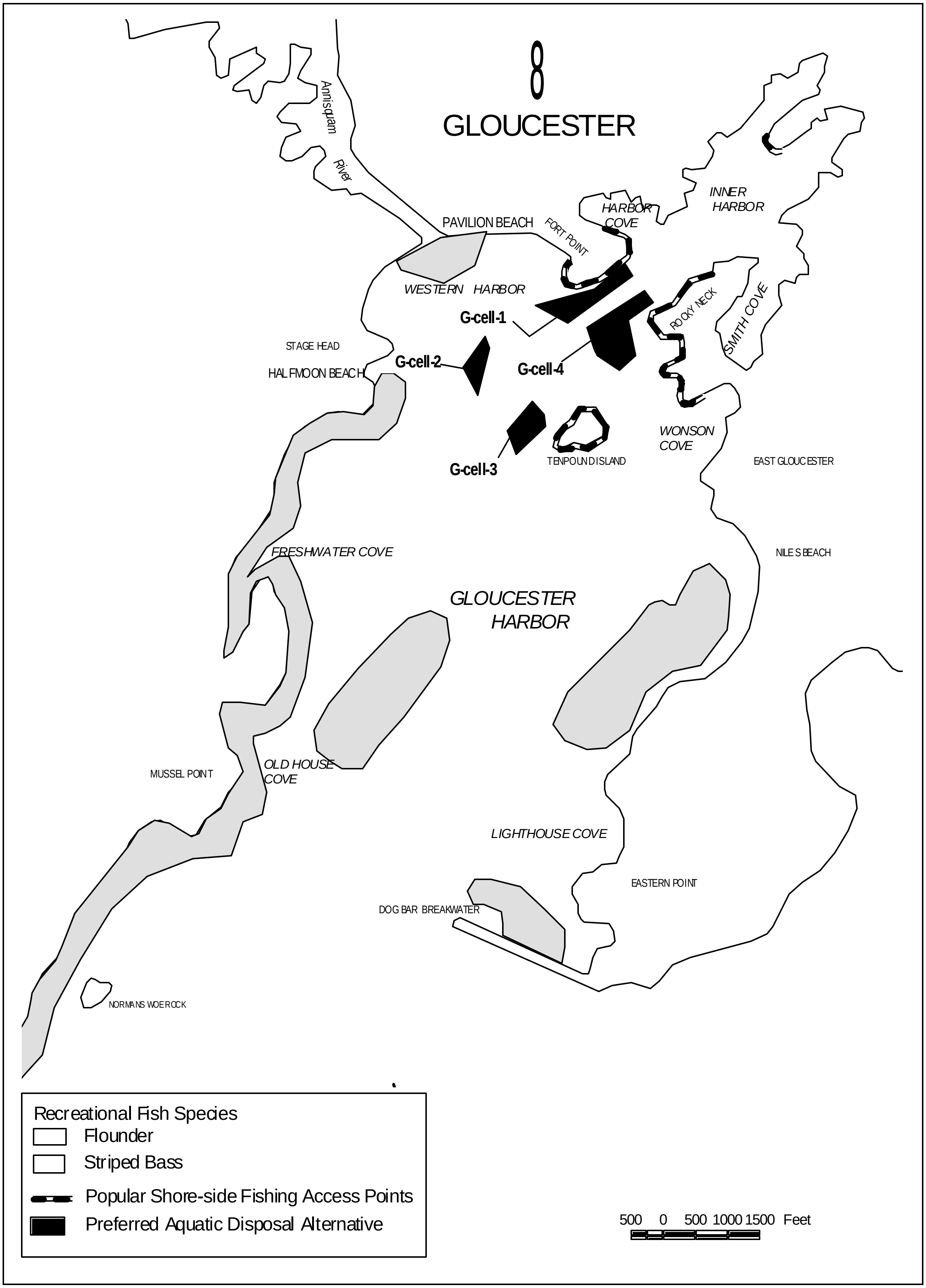

Figure 5-20: Recreational Fishing Areas in Gloucester Harbor.

Table 5-10: Important recreational fish species, their habitat, and principal locations in the Gloucester Harbor area.

Species[1]	**Habitat**[1]	**Where common in Gloucester**
Winter flounder	muddy sand, cleaner sand, eelgrass beds	off Dolliver Neck; Southeast Harbor
Atlantic Cod	rocks and pebbles, gravel, sand, shells	not specified.
Atlantic mackerel	pelagic, schooling	throughout the harbor
Bluefish	pelagic, schooling	throughout the harbor
Striped bass	islands, rocks, sandy beaches	Freshwater cove, Mouth of Annisquam River
Tautog	ledges, rocks, piers	Dog Bar Breakwater, Harbor Ledges (e.g. Round Rock Shoal, Ten Pound Island Ledge, Prairie ledge).

[1] Source: Koutrakis 1997

[2] Source: Bigelow and Schroeder

Commercial Fishing

Commercial gill net fishing and lobstering is practiced outside Gloucester Harbor and in Salem Sound and more distant off-shore areas such as George's Bank. Since the G-Cell sites lie within Gloucester Harbor, all of the G-Cell aquatic disposal sites are within areas closed to mobile gear fishing (e.g. trawls, seines, dredges). Most of the commercial fishing effort is at depths of 60 feet or greater. Groundfish, particularly winter flounder, are the majority catch from January to June. From June to August dogfish move inshore and some fishermen remove their gill net gear in favor of lobster gear. As shown in Figure 4-38 (Sasnowski, et. al., 1998), coastal gillnetting (Area 1) is practiced in the winter months while commercial fishing in Area 2 is most prevalent from April to July. Deep water gillnetting (Area 3) occurs from January to August. Gloucester Harbor is more important to commercial fishing as a landing port. Fish landings for Gloucester, MA in comparison to Massachusetts statewide landings are provided in Table 5-11. Approximately half of all the haddock and silver hake landed in Massachusetts came into Gloucester Harbor in 1999. Seventy-eight percent of all white hake landed in Massachusetts came into Gloucester Harbor. Gloucester harbor also had significant percentages of other species landed in Massachusetts in 1999 such as American Plaice (41.5%) and Witch Flounder (37.0%). The majority of landings come from offshore fishing grounds.

Table 5-11. Fish Landings (lbs) for Gloucester Harbor and Massachusetts Statewide from May-December, 1999 (x1000)

Fish Species	Pounds Landed in Gloucester	Pounds Landed in Massachusetts (Statewide - All Ports Combined)	% of State Total Landed in Gloucester
Cod	2,320	11,721	19.8
Haddock	1,651	3,533	46.7
Yellow-tailed Flounder	592	4,915	12.0
White Hake	1,204	1,539	78.0
American Plaice	998	2,402	41.5
Winter Flounder	256	6,426	4.0
Witch Flounder	590	1,590	37.0
Window Pane	2	65	3.1
Silver Hake	2,065	3,996	51.7
Monk Fish	2,220	15,990	15.1

Source: NMFS (1999)

Lobstering within Gloucester Harbor (Figure 4-39) occurs primarily from April to September, which is outside of the DEP-designated dredging/disposal window, but may continue until December. Deeper waters (Areas 2, 3 and beyond) are more commonly fished from late spring/summer to early/mid winter.

Because of their mobility and natural changes in environmental conditions from season to season and year to year, the location of good lobster grounds can vary at any time. However, the anecdotal information given above does indicate some general differences in lobstering between in-shore and off-shore areas. Lobstering is practiced in deeper waters nearly year-round including fall and winter months when dredging and disposal would occur. Coastal lobstering is most intensive from April to August, but does continue at lower levels until December.

5.3.4 Coastal Wetlands, Submerged Aquatic Vegetation and Intertidal Flats

The following subsections discuss coastal wetlands, submerged aquatic vegetation and intertidal flats, their presence within and near the preferred disposal sites, their ecological importance, and their regulatory status under the Massachusetts Wetlands Protection and and Federal Clean Water Act.

5.3.4.1 Coastal Wetlands

The Massachusetts Wetland Protection Act, 310 CMR 10.21 through 10.37, regulates coastal wetlands including numerous submerged and intertidal resource areas. Salt marshes are areas with the most stringent protection under the Act (See Section 7.1.3). In addition, the following resources are regulated under the Act: Land Under Ocean; Coastal Beaches; Coastal Dunes; Barrier Beaches; Coastal Banks; Rocky Intertidal Shores; Salt Marshes; Land Under Salt Ponds; Land Containing Shellfish; Banks of or Land Under the Ocean, Ponds, Streams, Rivers, Lakes or Creeeks that Underlie Anadramous/Catadramous Fish Runs; and, Estimated Habitats of Rare Wildlife (for coastal wetlands).

The Wetland Protection Act regulations define a salt marsh as “a coastal wetland that extends up to the high tide line, that is, the highest spring tide of the year, and is characterized by plants that are well adapted to or prefer living in, saline soils. Typically dominant plants within salt marshes are salt meadow cord grass (*Spartina patens*) and/or salt marsh cord grass (*Spartina alterniflora*) ”.

Salt marshes are also protected under federal law because they are wetlands; one of the “special aquatic sites” designated in the Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material (40 CFR 230, Subpart E). The regulations describe possible impacts on these sites from dredged disposal, and the applicant for a dredging permit must demonstrate compliance with guidelines for avoiding adverse impacts to these areas before a permit can be issued. (See Section 7.2.5.3).

Massachusetts DEP Environmental Sensitivity Index mapping depicts salt marshes proximal to Gloucester Harbor along the Annisquam River and within limited areas of the south end of Freshwater Cove (west of Dolliver Neck) (Figure 5-21). These areas lie outside the footprint of the G-Cell sites.

5.3.4.2 Submerged Aquatic Vegetation

Vegetated shallows (a.k.a. submerged aquatic vegetation) are regulated by DEP as “Land Under Ocean”, and are also Special Aquatic Sites protected by the federal 404(b)(1) guidelines, where they are defined as “permanently inundated areas that under normal circumstances support communities of rooted aquatic vegetation”. In marine settings north of Cape Cod, eelgrass (*Zostera marina*) beds are the most common form of SAV. Eelgrass beds increase species diversity and productivity by providing substrate shelter and food for a variety of marine fish and invertebrates (Levington, 1982). They also stabilize marine sediments (reduce erosion and resuspension within the water column) by reducing wave energy. The formation of Eelgrass beds are also the first step in saltmarsh succession (Gosner, 1978).

Eelgrass beds in Gloucester Harbor were mapped by the DEP in 1997 from aerial photographs (Costello, 1997) (Figure 5-21). These resource areas are also depicted on draft Massachusetts DEP Environmental Sensitivity Index mapping of Gloucester Harbor (NOAA, 1998). Submerged aquatic vegetation (eelgrass beds) of Gloucester Harbor occur within areas of the many harbor embayments. Specifically, eelgrass beds are known to exist within the western and central regions of the Western Harbor, throughout the Southeast Harbor, the north and south sides of Black Bess Point, and within Lighthouse Cove. The nearest eelgrass bed to any of the G-Cell sites is the Western Harbor bed which lies approximately 740 feet (225 meters) northwest of G-Cell-1.

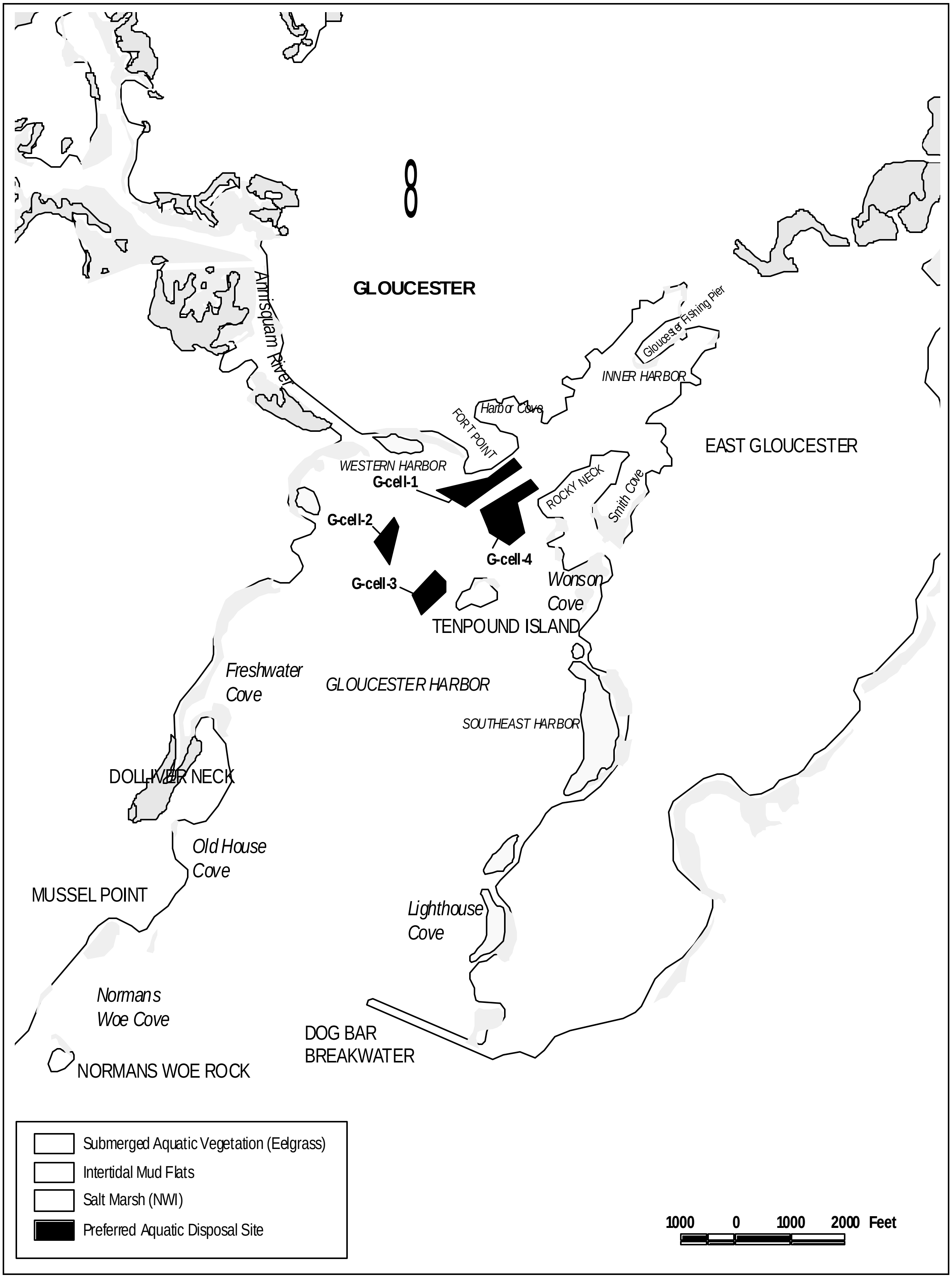

Figure 5-21:. SAV, Intertidal Mud Flats, and Salt Marsh in the Vicinity of the Preferred Disposal Sites.

5.3.4.3 Intertidal Habitats

The only areas other than wetlands and vegetated shallows, which are specifically protected under the 404(b)(1) guidelines and found in the Gloucester coastal area, are mud flats. These are defined as follows in the federal guidelines:

> *"Mud flats are broad flat areas along the sea coast and along coastal rivers to the head of tidal influence and in inland lakes, ponds, and riverine systems. Wind and wave action may resuspend bottom sediments. Coastal mud flats are exposed at extremely low tides and inundated at high tides with the water table at or near the surface of the substrate. The substrate of mud flats contains organic material and particles smaller in size than sand. They are either unvegetated or vegetated only by algal mats."*

This definition differs from the state's definition of tidal flats principally in that mud flats are composed only of fine-grained material, whereas tidal flats may also include intertidal sand bars. Mud flats contain biota such as clams and marine polychaete worms, and may provide foraging and nursery areas for fish and foraging habitat for shorebirds.

Tidal flats (either mud flats or sand bars) generally occur along the Annisquam River and within the many embayment areas of Gloucester Harbor such as Freshwater Cove, Western Harbor, Wonson Cove, Southeast Harbor, and Lighthouse Cove. Smith Cove, within Gloucester Inner Harbor, has an extensive tidal mud flat at its southern end. The Rocky Neck Peninsula separates this mud flat from the G-Cell site areas. Available mapping for Gloucester Harbor (NOAA, 1998) depict the nearest tidal flats to lie within 420 feet (128 meters) east of G-Cell-4 within a small embayment on the west side of Rocky Neck, and within 460 feet (140 meters) north of G-Cell-1 offshore of Pavillion Beach. Figure 5-18 depicts other tidal flats within the harbor in relation to the G-Cell sites.

5.3.5 Wildlife

The coastal waters off Gloucester and within Gloucester are inhabited by wintering waterfowl. Seabirds and shorebirds also frequent the various coastal habitats within and proximal to Gloucester Harbor. The areas within the harbor and immediately offshore are not known to support any significant concentrations of marine mammals or reptiles. All wildlife in the area is mobile and will avoid any areas of disturbance.

5.3.5.1 Avian Habitats

In the Gloucester area, beaches and tidal flats exist mainly in the protected embayment areas of the main Harbor, and along the Upper Annisquam River area. The G-cell sites are not located in an eelgrass, intertidal flat or salt marsh habitat, therefore, they are not within potential shorebird breeding or foraging habitat. Nevertheless, the eelgrass and intertidal flat areas proximal to the G-Cell sites (Figure 5-18) are habitat for diving ducks, shorebirds, and seabirds. A general discussion of the waterfowl, shorebird, and seabird habitats of Gloucester Harbor is presented below.

Waterfowl

Diving ducks (Family Anatidae, Subfamily Anatinae, Tribes Aythyini and Mergini) can be found within Cape Ann embayments, including Gloucester Harbor at any time of year, however most species are typically absent from June to July (Forster, 1994). Species richness and total abundance is greatest by late November when many farther north breeding sea ducks have arrived in the waters of eastern Massachusetts as winter residents. The total abundance may fluctuate throughout late fall to mid-winter months with the arrival and departure of somewhat transient loose flocks and individuals. Species richness and total abundance usually increases once again in late winter to early spring as the wintering waterfowl begin to stage for their flights to northern breeding grounds (Leahy, 1994).

The abundance of wintering waterfowl during diurnal cycles is usually greatest in nearshore (littoral) waters during mid to high-tide. During low tide, many of the deeper-diving species such as the seaducks and mergansers (Tribe Mergini) move out to deeper, off-shore waters (Leahy, 1994). The various species of diving ducks found within Gloucester Harbor include representatives of the herbivore (e.g. Redhead, *Aythya americana*), piscivore (e.g. Red-breasted Merganser, *Mergus serrator*), and molluscivore (e.g. Common Eider, *Somateria mollissima*) feeding guilds. Surface feeding ducks (Tribe Anatini) may also be found wintering within Gloucester Harbor, foraging in littoral waters for aquatic vegetation and invertebrates (e.g. Black Duck, *Anas rubripes;* American Widgeon, *Anas americana*, etc.).

Other waterfowl to be expected within Gloucester Harbor other than ducks include the loons (Family Gaviidae), grebes (Family Podicipedidae) and cormorants (Family Phalacrocoracidae). In the Cape Ann region, including Gloucester Harbor, loons and grebes are mainly absent as summer residents, but tend to be rare to locally common winter residents (Viet and Petersen, 1993). The species of loons (e.g. Common - *Gavia immer* and Red-throated - *G. stellata*) and grebes (e.g. Horned *Podiceps auritus* and Red-necked *Podiceps grisegena*) reported by Forster (1994) to winter in coastal eastern Massachusetts embayments (including Gloucester Harbor) feed mainly on fish by diving in open waters (Terres, 1980).

Of the cormorants, Double-crested Cormorants (*Phalacrocorax auritus*) are most abundant during the summer months, while Great Cormorants (*Phalacrocorax carbo*) appear in the harbor in winter months. However, either may be expected to be present at all times of the year as is reported for Nahant Bay, located to the south of Gloucester Harbor (Rines and Stymeist, 1994). Nearshore (littoral) and off-shore waters are used for feeding. Both species of cormorant feed primarily on fish (such as sculpins, haddock, cod, flounders, and herrings) but crustaceans such as spider crabs and shrimp may also be consumed (Terres, 1980). Food is caught by diving in open water areas. However, the harbor’s reefs and rocky promontories are used by these species for roosting and sunning.

Shorebirds

Shorebirds are also expected to frequent Gloucester Harbor. Numerous species of shorebirds such as the plovers (Family Charadriidae), and sandpipers (Family Scolopacidae) can be expected to frequent the intertidal flats of Gloucester Harbor throughout the seasons. Typically, species richness and abundance of shorebirds is generally greatest on exposed mudflats and sandy beaches at low tide during autumn migration (late summer to early fall) with peak occurrences for various species

varying throughout this time period (Forster, 1994). Although many species of shorebirds frequent mudflat habitat for feeding, some prefer pebbly or cobbly beaches (e.g. Ruddy Turnstone, *Arenaria interpres*) and others prefer rocky coast (i.e. Purple Sandpiper, *Calidris maritima*). However, as many as 15 species of shorebirds have been reported (many routinely) from the rocky ledges of nearby Halibut Point in Rockport (Leahy, 1994).

Shorebirds feed mainly on marine polycheates, amphipods, and even mollusks (Terres, 1980) on tidal flats, intertidal rocks, and shallow subtidal bottoms (Levinton, 1982). These food sources tend to be more easily accessible to the birds during low tides, therefore diurnal cycles of abundance and species richness will be greatest during low tides. Sandpipers and plovers feed on surface-dwelling invertebrates such as amphipods and marine worms by gleaning from the surface or turning over stones. Larger shorebirds, such as dowitchers, whimbrels and willets, probe the soft substrata using their long bills (Levinton, 1982).

5.3.5.2 Marine Mammals

Marine mammals found in the waters in and around Stellwagen Bank located approximately 4.5 to 5 miles east southeast of Gloucester, include thirteen species of cetaceans (whales and porpoises), and two species of seals (NOAA, 1993)(Table 5-12). Although five of the whale species are endangered, some, especially the large and conspicuous humpback (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*), have become locally common enough to support a whale-watching industry. As of the end of 1998, this industry produced revenues of $20,000,000 per year and brings 860,000 people annually to Stellwagen Bank to view whales (Boston *Globe*, January 11, 1999). Most of these species may be expected to be found occasionally in the ocean waters closer to Gloucester, but rarely, if ever, within the harbors. An exception to this is the harbor seal *(Phoca vitulina*), which from late September to late May is commonly seen resting on sheltered and undisturbed rocky ledges in harbors, bays and estuaries from Maine, south to Plymouth, Massachusetts and occasionally beyond.

Table 5-12. Marine mammals found in the waters over and around Stellwagen Bank (NOAA, 1993)

Common Name	Scientific Name	Remarks
Humpback whale	*Megaptera novaeangliae*	March-November, offshore, near bank
Northern right whale	*Eubalaena glacialis*	Late winter - July
Fin whale	*Balaenoptera physalus*	Peak April - October, offshore
Sei whale	*Balaenoptera borealis*	Very rare
Blue whale	*Balaenoptera musculus*	Very rare
Minke whale	*Balaenoptera acutorostrata*	Peak spring - late summer/early fall
Pilot whale	*Globicephala* spp.	(2 species)
Killer whale	*Orcinus orca*	Peak mid-July through September
White-sided dolphin	*Lagenorhynchus acutus*	Common all year
White-beaked dolphin	*Lagenorhynchus albirostris*	Rare, April - November
Harbor porpoise	*Phocaena phocaena*	Peak in spring
Bottlenose dolphin	*Tursiops truncatus*	Late summer/fall, offshore
Common dolphin	*Delphinus delphis*	Occasional, fall/winter, offshore
Harbor seal	*Phoca vitulina*	Common, nearshore
Gray seal	*Halichoerus grypus*	Abundant in Canada, rare in Massachusetts

5.3.5.3 Reptiles

The only marine reptiles found in the project region are sea turtles. Although four species of sea turtles have been recorded in the Gulf of Maine, only two, the leatherback (*Dermochelys coriacea*) and the Atlantic ridley (*Lepidochelys kempi*), are seen with any regularity (Payne 1991). The leatherback, the largest living reptile, may grow to 11 feet (3.3 meters) in length and weigh up to 1900 pounds. Leatherbacks breed in Central and South America and are most frequently sighted off Massachusetts from June through September.

The Atlantic or Kemp's ridley is the most commonly reported turtle from Cape Cod Bay (Payne, 1991), but most of the sightings are of stranded juveniles. Individuals of this warm-water species breed in Mexico, drift or swim north as juveniles, and become trapped in Cape Cod Bay as temperatures fall, where they are killed by the cold. They are not an important part of the fauna near Gloucester. The other two species of turtles reported for the area, loggerhead (*Caretta caretta*) and green turtles (*Chelonia mydas*), are very rarely found north of Cape Cod. Sightings of these two species north of Cape Cod are usually wandering juveniles that do not survive the winter (Weiss, 1995).

5.3.5.4 Endangered Species

The Massachusetts Natural Heritage Atlas does not indicate any estimated habitat of state-listed Endangered, Threatened or Special Concern species in or adjacent to the marine waters of the Gloucester area with the exception of Tinkers Island located approximately 10.5 miles to the southwest of Gloucester Harbor. It does not indicate any priority sites of rare species habitats or exemplary natural communities in this area.

Of the marine mammals and reptiles reported on in Section 5.1.6.2, five whales and two turtles are federally listed as endangered. These include the humpback whale, fin whale, sei whale, blue whale, northern right whale, leatherback turtle and the Atlantic or Kemp's ridley turtle. These species, if they attain enough numbers to have centers of concentration at all, are found mainly at Stellwagen Bank off the northern tip of Cape Cod or at Jeffrey's Ledge north of Cape Ann.

5.3.6 Historical and Archaeological Resources

5.3.6.1 General

The Port of Gloucester is rich in colonial maritime history. First visited by Samuel de Champlain in 1603, it was soon settled by colonists from Plymouth and became established as a commercial fishing port in 1632. It is the oldest commercial fishing port in the nation. Gloucester history is preserved in several museums and exhibits in the region including, the Essex Shipbuilding Museum, the Cape Ann Historical Museum, and the Sargent House Museum, among others. In addition, Rocky Neck Avenue in East Gloucester has been designated the oldest working artist colony in America by the Smithsonian Institution. Because of Gloucester's maritime historical significance, a reconnaissance survey of the potential shipwrecks and aboriginal (Native American) sites in the Harbor was conducted.

As requested by the Massachusetts Board of Underwater Archaeological Resources, a reconnaissance survey was conducted to identify the potential for historical (shipwrecks) and archaeological (aboriginal) sites for the Gloucester DMMP. The full survey report in included in Appendix I.

5.3.6.2 Historical Shipwrecks

To determine significance for each shipwreck the Department of the Interior's definition of eligibility for the National Register of Historic Places (i.e. generally sites over fifty years old) was used as guidance. However, most of the shipwrecks were over one hundred years old. Because the recording of shipwrecks was not done in a thorough and programmed manner in the 19th and early 20th century, the information for any particular site might be inaccurate. However, the approximate number of significant shipwreck sites in the Gloucester study area is accurate enough to allow the determination that pre-dredging/disposal planning is recommended.

The survey-level historical research located a total of 349 shipwrecks in the Gloucester aquatic ZSF, including vessels listed as lost “off” Salem, Marblehead, Beverly, Manchester, or Gloucester. Eliminating those vessels known to be outside of any of the candidate disposal sites, we are left with 5 shipwreck sites known to be within in, or close to, the original aquatic disposal candidate sites and

317 at some unknown spot in the ZSF. Of the latter two groups, 302 would fit the Department of the Interior’s eligibility for the National Register of Historic Places (Reiss, 1998).

Located wrecks are shown in Figure 5-22. There are no known shipwrecks near the preferred aquatic disposal sites. The closest mapped wrecks to the G-cell sites are the Nina T (ca. 1990), and the Chester Poling (ca. 1977) located outside of Gloucester Harbor approximately 1,000 feet (305 meters) and 1,100 feet (335.3 meters) southeast of Dog Bar Breakwater.

In addition to those vessels found in the historical records, we must assume many others were lost in the study area and not recorded. Before radios and radar, vessels were surely lost with all hands on the numerous ledges in the area during storms and fogs. Others could only record them as missing at sea, whether they had just left the harbor, were returning after a long voyage, or were blown in while trying to sail past the shore. No one would know what happened to them. They would include small and large fishing boats, coasters, and transoceanic merchant men and warships.

Besides those vessels lost while underway, a number would have been lost at their moorings or abandoned in shallow water, such as the abandoned 1800s fishing vessel seen at low tide on the western shore of Manchester Harbor and the 1690s Hart's Cove shallop in Newcastle, New Hampshire. Some of the shipwrecks would have been salvaged shortly after wrecking or more recently.

Since we know so little of the early vessels, onboard fishing processes, or life aboard the early merchant vessels, the remains of any historic ship or boat would be archaeologically and historically significant on a local, regional, and national level.

Historic shipwreck sites are known to exist in the study area and are relatively easy to detect. The number of vessel losses found in this study is smaller than the total losses that would be located with a complete study, but the results found are indicative of a large number of probable shipwreck sites within or proximal to the Harbor. The lack of complete recorded evidence is typical for any locality along the New England shore. Until recently the loss of a vessel, even with the loss of life, was not considered newsworthy enough for the ubiquitous 4-page weekly newspaper in the 1700s and 1800s. State and federal government compilations of vessel losses, which are incomplete, date only from the very late 1800s. In addition, the parameters of this study only included some primary research with mostly the inspection of secondary compilations of data from the primary sources. The data located in this study indicate that there is a probability of encountering the remains of an historic vessel in or near the G-Cell sites, although because this area was dredged for the creation of the Federal Channel, the remains of a shipwreck may have already been removed, wholly or in part.

Field surveys of the G-Cell sites and vicinity will be conducted to ascertain if any shipwrecks or shipwreck debris is present. See Appendix I for more information on potential future studies.

5.3.6.3 Archaeological Sites

Prehistoric Indians (Native Americans) used the shore as a summer dwelling area to get away from the heat and insects of the interior and to collect the bountiful food offered by the sea. Regionally, Indians were known to collect many types of shellfish which were smoked, dried, stored and traded for winter food. They used small dugout and bark canoes for fishing and hunting mammals, and for transportation along the shore and to nearby islands.

In most areas of New England, seasonal Indian dwelling sites are typically found near a beach and a fresh water source with a southeast exposure to the sea. In addition, shell middens, created by Indians processing bivalves, are often found in similar areas without the need of running fresh water (Bourque, 1980, IV-45-49 & Riess, 1989, 12). Since the last ice age, the net sea level change has placed the coastline of 6,000 BP under approximately 25 feet (7.62 meters) of water in the Cape Ann area (Bourque, 1980, IV-229). For example, some of the islands now close to shore near Gloucester would have been small hills connected to the mainland by low strips of land as recently as 2,000 years ago. If they were close to a beach, which might have been part of the connecting strips, they would have been prime areas for prehistoric residential use.

Since little is known of the prehistoric Indians of the study area, any remains, whether a village, fish processing site, or sunken canoe, would be of great importance. However, previous sub-bottom profiling data indicate that the area has an irregular bedrock surface which is typically covered by 0-30 feet (0 to 9.1 meters) of glacially deposited medium sand and some organic and clay sediment.

Remains of any sites would be extremely hard to locate under the sediment in the survey area. Remote sensing surveys will generally not indicate a prehistoric site in this type of topography. Locating prehistoric Indian sites would require archaeological trenching of each proposed impact area. Spot inspection by archaeological divers, while investigating remote sensing targets of possible historic remains, would be useful, but probably not productive.

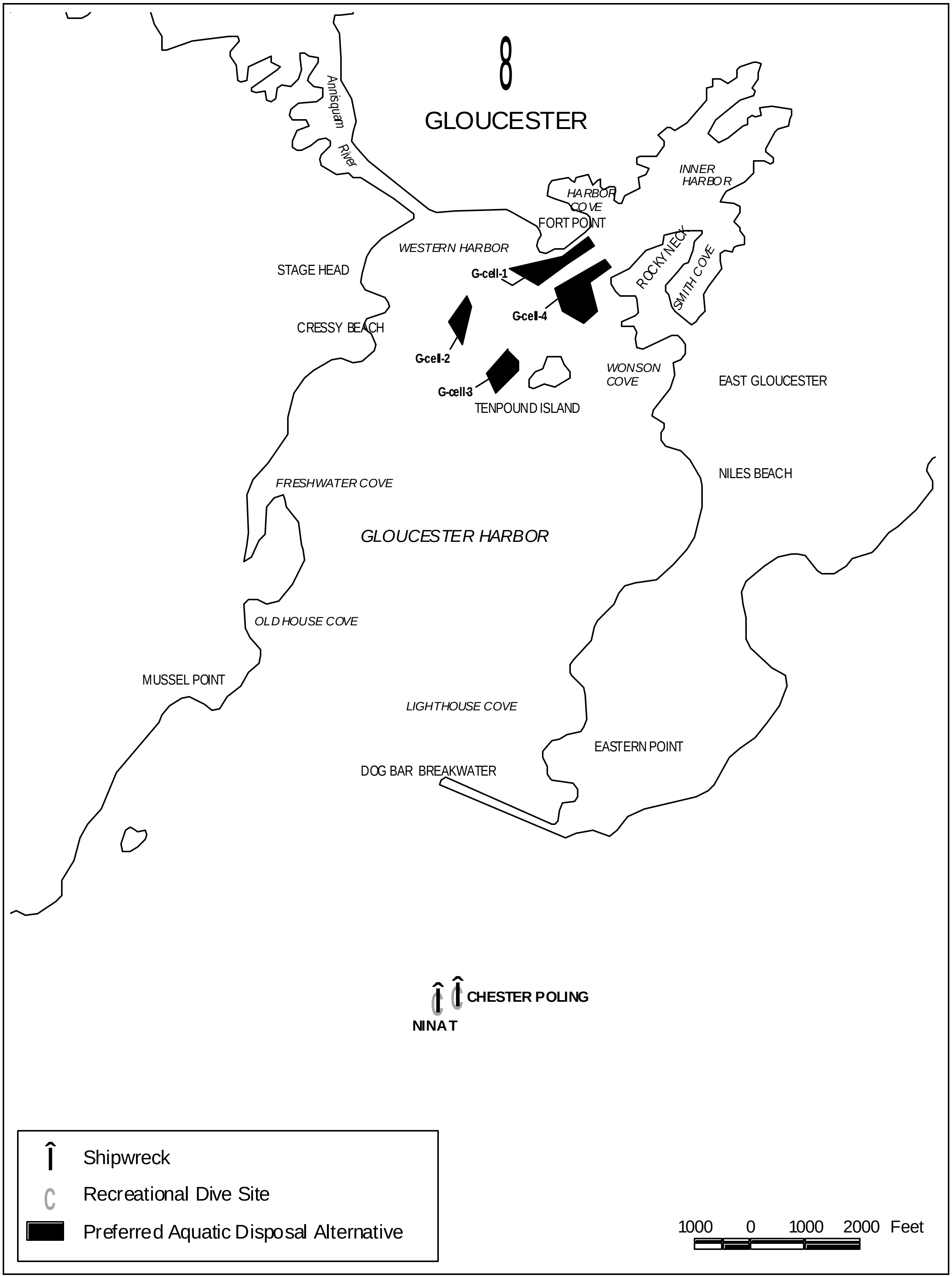

Figure 5-22: Known Shipwreck Locations in Gloucester Harbor.

5.3.7 Navigation and Shipping

Gloucester Harbor is the oldest fishing port in the nation, and the second largest commercial fishing port in New England (second only to New Bedford). The Gloucester Main Harbor is deep enough along the main navigation channel, and does not require maintenance dredging. However access to the commercial areas of the port within the Inner Harbor is provided through the dredged federal navigation channel (Figure 5-2) which has an authorized navigational depth of 20 feet (6.1 meters). Maintenance of the dredged federal navigation channel in Gloucester Harbor is required to support the Harbor's role as a commercial fishing port. With further expansion of the port and waterfront facilities, the need for additional commercial deep water berthing in the harbor exists. In many areas of the Harbor, there is insufficient water depth to accommodate large commercial vessels at some of the existing harborside facilities.

Recreational vessel traffic also plays a large role in Gloucester Harbor. The harbor contains approximately 16 marinas or boat yards, approximately three yacht clubs and three dockside restaurants. There is a significant recreational boating fleet, with numerous moorings distributed within three mooring basins. Gloucester Harbor is a significant recreational boating destination, due to the large number of historical and cultural attractions of the town, largely located adjacent to or within close proximity to the Inner Harbor.

The entrance to Gloucester Harbor lies west of Round Rock Shoal and The Dog Bar Breakwater. Entrance to the Inner Harbor is via the main Federal Channel which begins at a point just southwest of an imaginary line from Fort Point to Rocky Neck. The entrance channel maintains an average depth to MLW of 15.5 feet (4.7 meters) across an approximate width of 300 feet (91.4 meters) and along its approximate 3900 foot (1188 meter) length.

At the northeastern end of their entrance channel, the channel splits into north and south channels, which are separated by first, an anchorage area, then rock shoals, and finally by the State fish pier. The North Channel maintains a depth of 17 feet (5.2 meters) MLW and an average width of 200 feet (61 meters) for an approximate length of 2,350 feet (716 meters) long. The South Channel maintains a depth of 18 feet (5.5 meters) MLW and an average width of 200 feet (61 meters) for an approximate length of 2,300 feet (701 meters) long. The anchorage at the intersection of the North and South Channels has an approximate depth of 16 feet (4.9 meters). The two major embayments of the Inner Harbor, Harbor Cove to the northwest and East Gloucester Harbor to the southeast (at the entrance to Smith Cove) have an average depth of approximately 15 feet (4.6 meters) and 13 feet (4 meters), respectively.

The Blynman Canal provides navigable access along the Annisquam River. It is accessed from the Western Harbor area of the Gloucester Main Harbor. The Blynman Canal provides access for recreational and fishing vessels to the Annisquam River. The Blynman Canal has a navigation depth of 6.7 feet (2 meters) from the entrance at the Western Harbor, north to the B & M Railroad Bridge. This segment of the canal has a mean width of 30 feet (9.1 meters). From the B & M Railroad Bridge, north to Bouy No. 21, the canal has an average depth of 4.7 feet (1.4 meters) MLLW and average width of 50 feet (15.2 meters) (NOAA, 1992).

5.3.8 Land Use

Land use along Gloucester Harbor in the vicinity of the preferred aquatic disposal sites, is a mixture of undeveloped, residential, commercial and industrial usage (Figure 5-2). G-Cell-1 lies adjacent to the western and southwestern sides of Fort Point. The western waterfront of Fort Point is developed with commercial facilities including Fuji Food, Parisi Seafood, and Cape Pond Ice. However, further landward, across Fort Point Avenue, lie residential areas. Residential and recreational land use areas also lie along the southeastern end of Fort Point. G-Cell-2 lies within an open water area of the Gloucester Main Harbor. The nearest land use is a public park (Stage Fort Park) located approximately 1155 feet (352 meters) to the west. G-Cell-3 lies proximal to Ten Pound Island which is mostly undeveloped. G-Cell-4 lies adjacent to residential land use areas of Rocky Neck approximately 200 feet (61 meters) to the south.

5.3.9 Air Quality and Noise

5.3.9.1 Air Quality

Background air quality in Gloucester Harbor has been estimated using monitoring data reported by the DEP to the USEPA Aerometric Information Retrieval System (AIRS). Although the DEP does not operate any air pollution monitors within the Town of Gloucester, data collected at other DEP monitors in Essex County during the three-year period of 1996-1998 were used to determine existing air quality of the region. The location of air quality monitoring stations within Essex County varies according to the parameter being measured and the year of data collection, and includes sites in Lawrence, Lynn, Newbury, Peabody, and Haverhill. This is a conservative approach, as the air quality in Gloucester is likely to be as good or better than that which exists near the monitoring sites. In particular, Gloucester is located farther from major industrial sources of air pollution than Lawrence or Lynn, with the PG&E Generating Station power plant in Salem being an exception. However Gloucester is upwind of Salem under the prevailing northwesterly wind. The Gloucester area also has significantly fewer mobile sources of air pollution, since its population density is less than that of either Lawrence or Lynn.

The USEPA mandates monitoring of the following six criteria air pollutants: nitrogen dioxide (NO_2), particulate matter with diameters less than or equal to 10 microns (PM_{10}), sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), and lead. Ambient Air Quality Standards (AAQS) have been established for each of these pollutants to protect the public health and welfare, with a margin of safety. PM_{10}, O_3, and NO_2 emissions are those associated with operation of heavy equipment used in UDM disposal operations. Ozone is not a pollutant emitted by heavy equipment, but is formed in the atmosphere when “precursor” elements and compounds such as nitric oxides, hydrocarbons (e.g. from unburned fossil fuels) and oxygen are combined in the presence of sunlight.

A geographic area that meets or exceeds an AAQS is called an attainment area for that air pollutant standard. An area that does not meet an air standard is called a non-attainment area for that standard. The entire state of Massachusetts is in attainment of all criteria air pollutant standards except for ozone, for which it is classified as in serious non-attainment. A summary of existing air quality data for Essex county is as follows:

Nitrogen Dioxide (NO_2): For the period of 1996-1998, no violations were recorded at either the Lynn or Newbury, MA monitoring locations. The 1998 annual arithmetic mean for the Newbury monitor was 0.006 ppm, which is only 11% of the standard. The 1998 annual arithmetic mean for the Lynn monitor was 0.014 ppm, or only 26% of the standard.

Particulate Matter 10-Microns (PM_{10}): Between 1996 and 1998, there were no violations of the PM_{10} air quality standards, which are (1) an annual arithmetic mean of 50 g/m^3, and (2) a 24-hour value of 150 g/m^3. The Lawrence monitor station readings had an annual arithmetic mean of 15 g/m^3, which was 30% of the standard.

Sulphur Dioxide (SO_2): The SO_2 monitoring site located closest to Gloucester is in Peabody, although no 1998 data was available from this site. SO_2 data was also collected from 1996-1998 at Essex County monitoring sites in Haverhill and Lawrence. The SO_2 standards are (1) 0.50 ppm (3-hour average, (2) 0.14 ppm (24-hour average), and (3) 0.03 ppm (annual mean). There were no violations of SO_2 standards in Essex county during 1996-1998. The 1997 annual mean in Peabody was 0.004 ppm, which is 1.3% of the standard. Similarly low measurements were recorded in Haverhill and Lawrence.

Ozone (O_3): During 1996-1998, O_3 was monitored in Essex County at sites in Newbury, Lawrence and Lynn. The air quality standard for O_3 is 0.12 ppm (one-hour standard). At Lynn, the maximum value recorded in 1998 was 121 ppm, which is 101% of the standard. The new 8-hour standard (0.085 ppm) is calculated as a three-year average of the annual fourth-highest daily maximum 8-hour O_3 concentration. From 1995-1997, Lynn had an 8-hour value of 0.089 ppm (105% of standard), and Newbury had a value of 0.084 ppm (99% of standard). Statewide, Massachusetts continues to be in non-attainment of the O_3 standard.

Carbon Monoxide (CO): Among the nine CO monitoring sites in Massachusetts, the sites closest to Gloucester are located in Lowell and Boston. Both of these urban locations can be expected to have higher ambient levels of CO due to higher population density and greater CO emissions from mobile sources. The CO standards are 35 ppm (1-hour average) and 9 ppm (8-hour average). During 1998 and 1997, there were no violations of the CO standards in Massachusetts. In Lowell, the maximum 1-hour value in 1998 was 6.0 ppm (17% of standard) and the maximum 8-hour value was 4.1 ppm (46% of standard). In Boston, the maximum 1-hour value in 1998 was 6.7 ppm (19% of standard) and the maximum 8-hour value was 6.6 ppm (73% of standard). In 1996, one violation of the 8-hour standard was recorded in Lowell (10.5 ppm).

Lead (Pb): Although lead is a criteria air pollutant, monitoring for lead was not conducted in 1997 because concentrations in Massachusetts have been minimal in recent years. The most recent available data for Essex County was recorded at monitoring sites in Newbury, Haverhill and Lynn during 1994-1995. The standard for lead is 1.5 µg/m^3 (quarterly mean). At all locations in Essex County, no value exceeded 0.01µg/m^3, which is less than 1% of the standard.

Overall, the existing air quality in the Gloucester area is good and is in compliance with all state and federal air quality standards except for ozone. Statewide non-attainment for the ozone standard requires that Massachusetts continue to make progress on implementing a State Implementation Plan (SIP) for attaining the standard.

5.3.9.2 Noise

Gloucester Harbor is a heavily commercialized port, and as such nearshore areas in Gloucester exhibit noise levels typical of commercial environments. Industrial noises, such as that associated with operation of a seafood processing plant or traffic noise from shipping and commerce, all contribute to the existing noise environment. Recreational areas, such as Stage Fort Park at the west end of the Gloucester Main Harbor, and residential areas, such as the Rocky Neck area, are generally quieter.

In the vicinity of the navigation channel and G-Cell sites, noise levels are typical of a mixed land use environment, quiet at some times, noisy at others. Most of the existing noise is generated from existing vessel traffic in the channel.

5.3.10 Recreational Resources

Recreational resources in Gloucester Harbor are abundant, and reflect a wide range of passive and recreational activities. Predominant among the recreational uses of the harbor are boating and sailing, swimming, and fishing. The harbor, as viewed from various locations around the perimeter, is often painted by artists from Rocky Neck.

There are sixteen recreational marinas or boat yards and approximately three yacht clubs located in Gloucester Harbor. In addition, numerous single point moorings are located within three major mooring basins. In addition, at least three dockside restaurants are located within Gloucester Harbor.

Recreational fishing is a significant activity, with winter flounder, cod, mackerel, bluefish, and striped bass the most important recreational species. Section 5.3.3.2 provides a more complete description of recreational fishing in Gloucester Harbor.

Public parks abutting Gloucester Harbor include Stage Fort Park at the western end of the harbor, (the site of the nation’s first commercial fishing stage), which provides public beach access and picnic areas. Smaller municipal parks are located along the waterfront on the western side of Fort Point, and in East Gloucester. These small municipal parks generally contain neighborhood playgrounds.

5.3.11 Economic Environment

Gloucester, founded in 1623, was among the first commercial seaports in colonial America. Gloucester Harbor’s natural attributes as a natural harbor refuge of the Commonwealth provided economic opportunity for the Town of Gloucester. Early economic activity in Gloucester Harbor centered upon fishing and timber interests (Riess, 1998). Cod, mackerel and haddock were fished off-shore stored in salt on the fishing vessels and processed on stages in the harbor. Gloucester Harbor was critical to the development of colonial Massachusetts and remained important throughout the colonial period. Trade duties collected from economic activity in Gloucester harbor fueled our emerging nation's economy and funded our fledgling independence. The local and regional economy grew around the fishing industry as Gloucester became the preferred port of call for off-shore fishing vessels. Gloucester rose to international prominence in the mid-nineteenth century as various factors led to continued expansion of the port. Railroads connected the harbor to farther potential fresh fish markets. With the onset of powered shipping, Gloucester lost its distinction as the preferred port of call for fresh fish in preference to Boston. This forced the fish processing industry within the harbor to change from fresh fish to first canned fish, then frozen fish by the 1940's. Gloucester remains an important fishing port in New England today (Riess, 1998). It is the second largest commercial fishing port in New England, second only to New Bedford. The Harbor contains numerous dealers, processors, and cold storage facilities associated with the industry.

While the review of regional economic data for Essex County, indicates a small percentage of marine related industries in Essex County, less than one percent of total employment (US Census Bureau, 1997), marine-related industry in Gloucester is actually substantial. By applying the percentage of Gloucester residents living and working in Gloucester, 58% (US Census Bureau, 1990), to the 1998 Labor Force, 16,017, adjusted for the 1998 Unemployment Rate, 5.3% (Massachusetts Department of Revenue, 2000) the City's percentage of resident jobs attributable to the Harbor is over 33%, when seasonal jobs are included.

The *Gloucester Harbor Plan* identifies the seafood industries and cultural and visitor activities as specific economic sectors directly related to the Harbor. Seafood industries are estimated to generate $700,000,000 and support 2,500 jobs. While the cultural and visitor sectors are estimated to account for $20,000,000 of the local economy while providing 430 permanent jobs and over 800 seasonal job opportunities (Gloucester, 1999). Table 5-13 shows the approximate number of jobs and estimated dollars generated for the seafood industries and cultural and visitor sectors as estimated in the Harbor Plan.

Table 5-13: Gloucester Harbor Economic Data - Employment

	Approximate # of Jobs	**Estimated $ Generated**
Seafood Industries	2,500	$700,000,000
Cultural and Visitor Activities	430 (+800 seasonal)	$20,000,000
Totals	2,930 (+800 seasonal)	$720,000,000

Source: Gloucester Harbor Plan, 1999

To quantify the total value in dollars of other maritime commercial activities, data for imports and exports were reviewed. Total imports for 1999, in Gloucester Harbor were valued at $17,219,968, representing a 28% increase over import values from 1998. Even with a decrease in total export weight between 1998, and 1999, export values for Gloucester Harbor in 1999, corresponding with an increase of 48% over 1998, exhibiting a total value of $5,727,637. The composite increase in total imports and exports is over 28% between 1998, and 1999, for a total value of $22,947,605 in 1999 (US Maritime Administration, 2000). Table 5-14 illustrates total weights and total values of imports and exports for 1998, and 1999.

Table 5-14: Imports and Export for Gloucester Harbor, 1998, and 1999

Year	Total Weight (Kilograms)	Total Weight (Short Tons)	Total Value (US Dollars)
Imports			
1999	5,170,237	5,700	$17,219,968
1998	3,908,220	4,309	$13,531,629
Exports			
1999	771,644	851	$5,727,637
1998	901,309	994	$2,940,354
Total Imports and Exports			
1999	5,941,881	6,551	$22,947,605
1998	4,809,529	5,303	$16,471,983

Source: US Maritime Administration, 2000